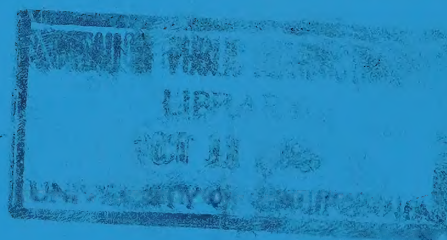


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REPORT ON

Reclamation and Development of Submerged Lands

CITY OF BERKELEY



TUDOR ENGINEERING COMPANY

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APRIL 1956 *to the Mayor and City Council*

REPORT ON

Reclamation and Development of Submerged Lands

CITY OF BERKELEY

TUDOR ENGINEERING COMPANY *San Francisco*



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TUDOR ENGINEERING COMPANY

74 NEW MONTGOMERY STREET, SAN FRANCISCO 5 - YUKON 2-4387

April 6, 1956

The Honorable Mayor and
Members of the City Council
City of Berkeley, California

Gentlemen:

Under date of November 8, 1955, Tudor Engineering Company was retained "to make an engineering study and report of the economic feasibility of reclaiming any or all of the City owned submerged lands off the Berkeley waterfront". All items of work under the contract have been completed and the final report is submitted herewith.

Of the various proposals which have heretofore been made for the reclamation and development of the City owned submerged lands, that shown on the Berkeley Master Plan is the most comprehensive. Unfortunately, it is probably not feasible of full accomplishment, primarily because of the depth of water, lack of sufficient local materials with which to fill so large an area and the high cost.

A variation of the plan providing some industrial area, extension of the Yacht Harbor, a waterfront park, a stadium and parking area and new sanitary disposal areas may be entirely feasible, if the projects can qualify under the existing State land grant restrictions and financing can be arranged. One such possible development is described in Section V of the report, and estimates of cost are presented.

The factor which has the dominant effect on feasibility of any reclamation program, is the character of the soil materials comprising the City owned submerged lands. Unfortunately, they are inferior both as a source of fill materials and as a base upon which to place them.

Any method of reclaiming the submerged lands will be costly. The least costly will be diking and unwatering. Land reclaimed by this method would be suitable, we believe, as a site for a stadium and parking area though it might not find acceptance for residential, business or industrial use.

Two possible restrictions upon reclamation and development should be noted. One is the established bulkhead line beyond which reclamation may not be extended until relocation of the bulkhead line is approved.

The other is the restriction contained in the State land grants of these submerged lands which limits their use to the establishment of a harbor and facilities for the promotion and accommodation of commerce and navigation.

Feasibility of reclamation and development will of course depend on availability of funds. Financial assistance might be forthcoming from the State and Federal governments for portions of the program.

A summary of Findings and Conclusions is presented on pages 45 to 51 inclusive.

We take this opportunity to express our appreciation for the co-operation and assistance given us by the Planning Staff and Department of Public Works of the City of Berkeley.

Very truly yours,

Carl A. Trexel
Carl A. Trexel

TUDOR ENGINEERING COMPANY

CAT/rm

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RECLAMATION AND DEVELOPMENT OF SUBMERGED LANDS

City of Berkeley

SECTION I - INTRODUCTION

This report has been prepared pursuant to a resolution of the Berkeley City Council, December 7, 1954 and a contract with Tudor Engineering Company dated November 8, 1955 "to make an engineering study and report of the economic feasibility of reclaiming any or all of the City owned submerged lands off the Berkeley waterfront."

Contract Tasks:

The contract tasks were set forth as follows:

- "(a) Review all reports listed in Berkeley City Planning Memorandum dated February 2, 1955 and other reports relating to land reclamation of similar character.
- (b) Compile ownership data on the privately held submerged lands in the City of Berkeley.
- (c) Consult with and ascertain land reclamation and related plans of the adjacent cities of Oakland, Emeryville, and Albany.
- (d) Consult with and ascertain plans of the Santa Fe Railway Company.
- (e) Consider the effect of land reclamation upon:
 - (1) Aquatic Park
 - (2) Berkeley Yacht Harbor
 - (3) Berkeley Municipal Pier
 - (4) Berkeley sanitary disposal areas
 - (5) Future Berkeley Airport

Introduction

- (6) Future additional East Shore Freeway
- (7) Existing storm sewers
- (f) Determine available borrow areas for fill materials and also mud disposal areas.
- (g) Determine the most economic method or methods of constructing the fills.
- (h) Discuss the matter of consolidation of fills.
- (i) Determine the most economic type of types or dikes and bulkheads.
- (j) Consider and discuss the feasibility of diking and unwatering areas of presently submerged waterfront.
- (k) Prepare and furnish estimates of cost of land reclamation including removal and disposal of unsuitable materials, new fill, dikes and bulkheads, extensions of storm drains, and provision of equal facilities for any facilities which are displaced by land reclamation operations. These estimates of cost will be arranged for stage development.
- (l) Make a general study and presentation of types of foundations suitable for buildings and other structures in the reclaimed areas.
- (m) Prepare and furnish estimates of time of construction for the various stages of construction.
- (n) Retain soils engineers, in connection with the study of foundation conditions and the soils problems associated with placing and consolidating the fills.
- (o) Prepare a comprehensive report containing the findings and recommendations of Company, said report to be suitably illustrated with charts, maps, graphs, and delineations."

Introduction

- (6) Future additional East Shore Freeway
- (7) Existing storm sewers
- (f) Determine available borrow areas for fill materials and also mud disposal areas.
- (g) Determine the most economic method or methods of constructing the fills.
- (h) Discuss the matter of consolidation of fills.
- (i) Determine the most economic type of types or dikes and bulkheads.
- (j) Consider and discuss the feasibility of diking and unwatering areas of presently submerged waterfront.
- (k) Prepare and furnish estimates of cost of land reclamation including removal and disposal of unsuitable materials, new fill, dikes and bulkheads, extensions of storm drains, and provision of equal facilities for any facilities which are displaced by land reclamation operations. These estimates of cost will be arranged for stage development.
- (l) Make a general study and presentation of types of foundations suitable for buildings and other structures in the reclaimed areas.
- (m) Prepare and furnish estimates of time of construction for the various stages of construction.
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- (o) Prepare a comprehensive report containing the findings and recommendations of Company, said report to be suitably illustrated with charts, maps, graphs, and delineations."

Introduction

All reports referred to have been reviewed and the Santa Fe Railway Company and the cities of Oakland, Emeryville and Albany have been consulted with reference to their reclamation and related plans. Dames & Moore, Soils Mechanics Engineers, were retained by us in connection with this study, and all other contract requirements have been met as will appear hereinafter in the report.

SECTION II - THE AREA TO BE STUDIED

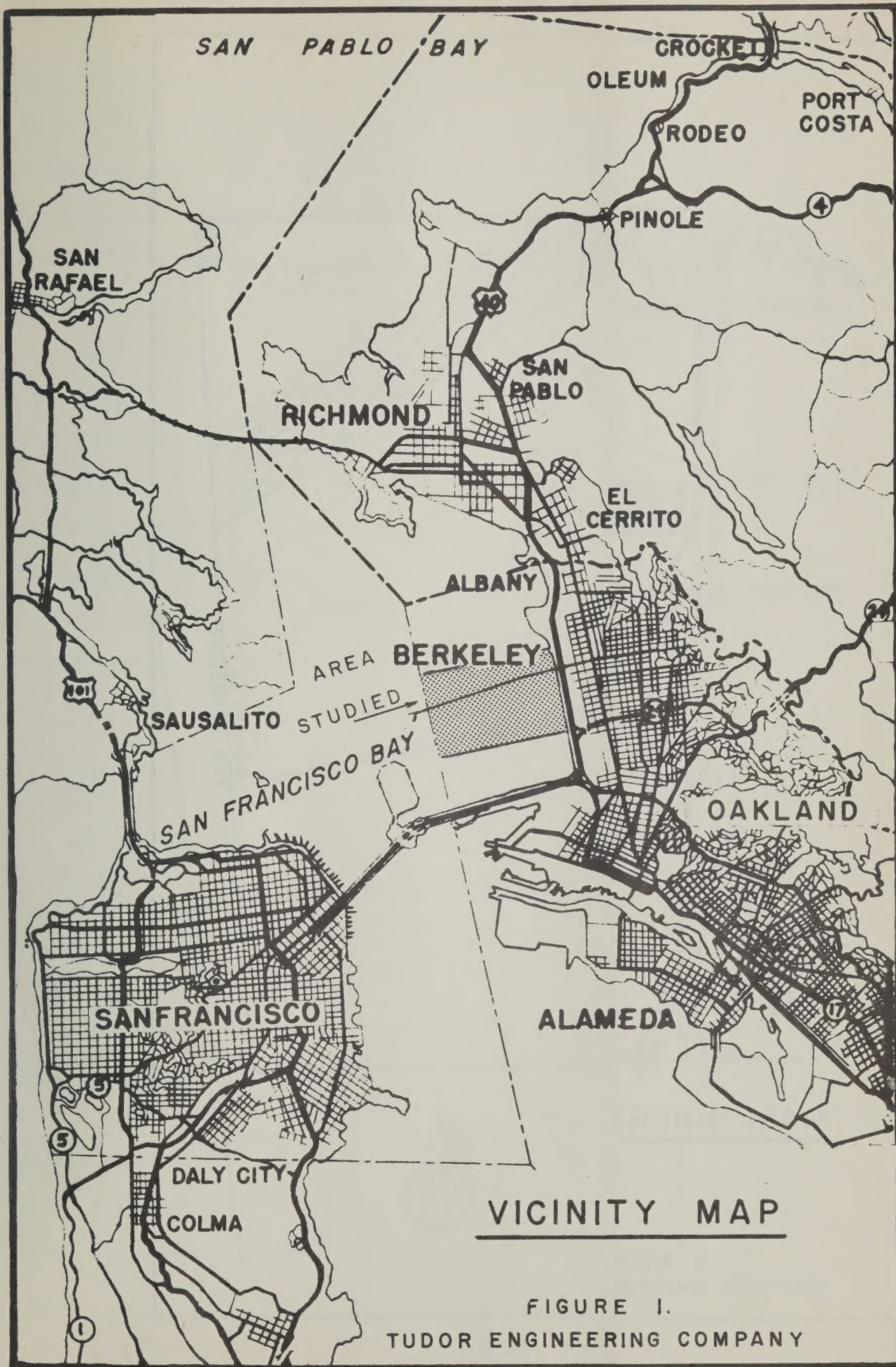
A. Location:

The area to be studied, all within the City limits of Berkeley, is shown on Figure 1, page 5. It consists of the tidelands and submerged lands extending about 2.4 miles along the Berkeley shoreline and about 3.3 miles westerly into San Francisco Bay. A part of this area along the shoreline is privately owned.

B. Property Ownership and Restrictions:

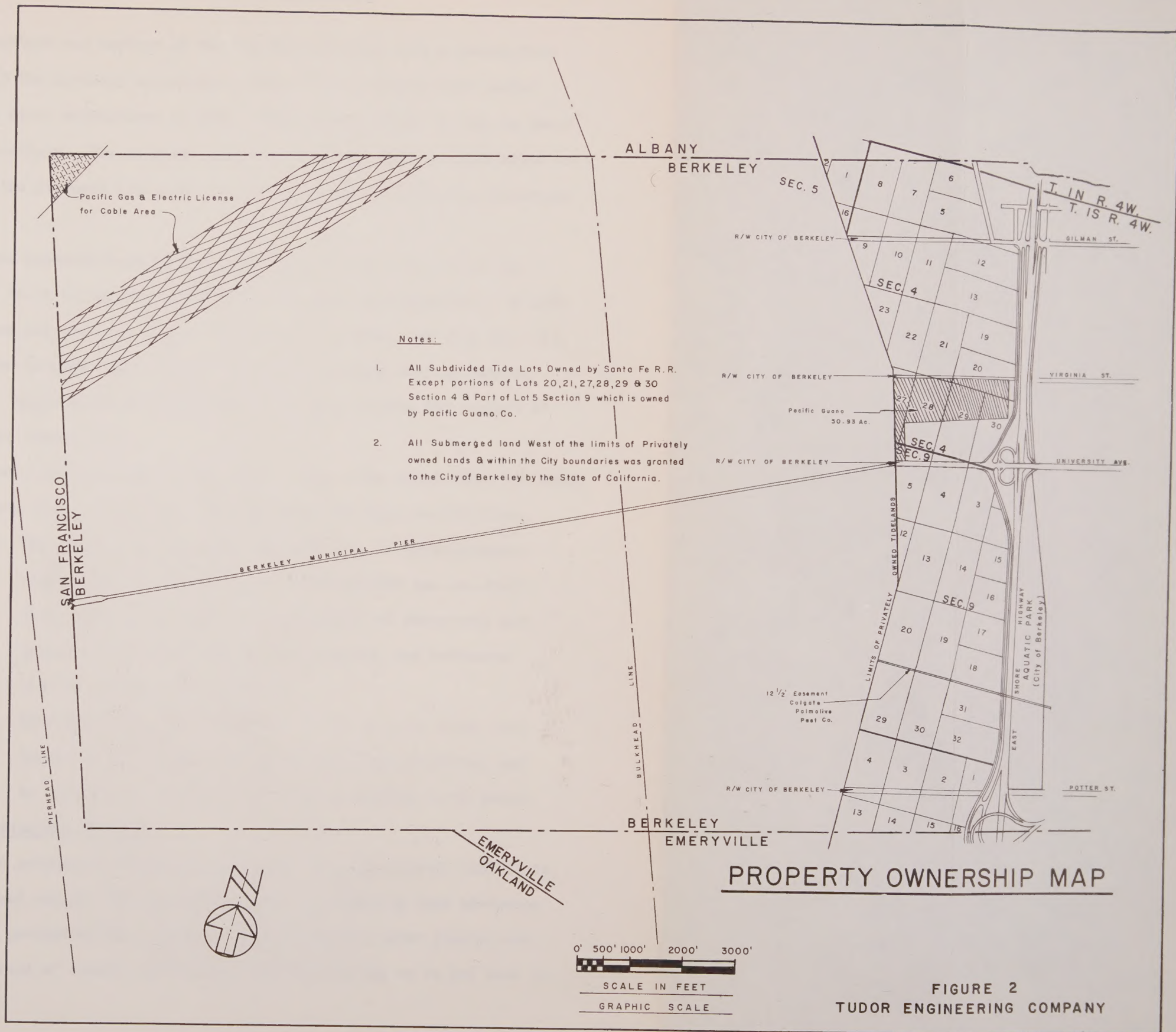
The City of Berkeley is the principal owner of these submerged lands, having received title under a 1913 grant, as amended in 1919, from the State. However, the lands adjoining the shoreline were subdivided and sold by the State to private owners prior to this grant by a Board of Tideland Commissioners created in 1870. The private ownership of these lands is shown on Figure 2, page 6. There are only two private owners, the principal one being the Santa Fe Railway Company which holds approximately 700 acres in the City of Berkeley and intends, at some future time, to relocate its main line tracks in the strip of tideland and to develop the property for industrial purposes. The Pacific Guano Company owns some 50 acres in Sections 4 and 9 as indicated in Figure 2, page 6.

There are also some additional interests which restrict the principal property ownerships. These are shown on Figure 2, page 6. The Pacific Gas and Electric Company has State licenses for cable crossings through the northwest corner of the offshore City property. These cable areas are closed to dredging. An easement for a pipe line across Aquatic Park and the Santa Fe properties is held by Colgate Palmolive Peet Company. Under the Federal Rivers and Harbors Acts, the U. S. Army Engineers have jurisdiction over all



VICINITY MAP

FIGURE I.
TUDOR ENGINEERING COMPANY



The Area to be Studied

navigable waters and harbors of the bay and therefore have a restrictive interest in the Berkeley waterfront. Under this responsibility harbor lines were first established in 1893. These were revised in 1913 to their present positions. The bulkhead line lies about one and one-half miles offshore and the pierhead line near the end of the present Berkeley Municipal Pier.

The establishment of these arbitrary harbor lines limits the placing of fills to the area between the bulkhead and shorelines. Between the bulkhead and pierhead lines no fills may be placed, and only pier type construction is permitted. These lines may be changed only by Federal authority. Application for change would probably require the support of the adjacent communities.

Under the State grant, the title to the State owned lands was transferred to the City in trust with the following principal restrictions:

1. That said lands shall be used only for the establishment, improvement and conduct of a harbor and for the construction, maintenance and operation thereon of structures and appurtenances necessary for the promotion and accommodation of commerce and navigation.
2. That the City shall not grant, convey, give or alien said lands for any purpose whatsoever, although franchises may be granted for a limited period not exceeding fifty years.

C. Geological Features:

The geological features of San Francisco Bay indicate that it is a drowned land valley, the outline of which was formed by land movements at an early geological age. Inundation occurred in a later glacial era during a period of coastal subsidence, creating the bay as we now know it.

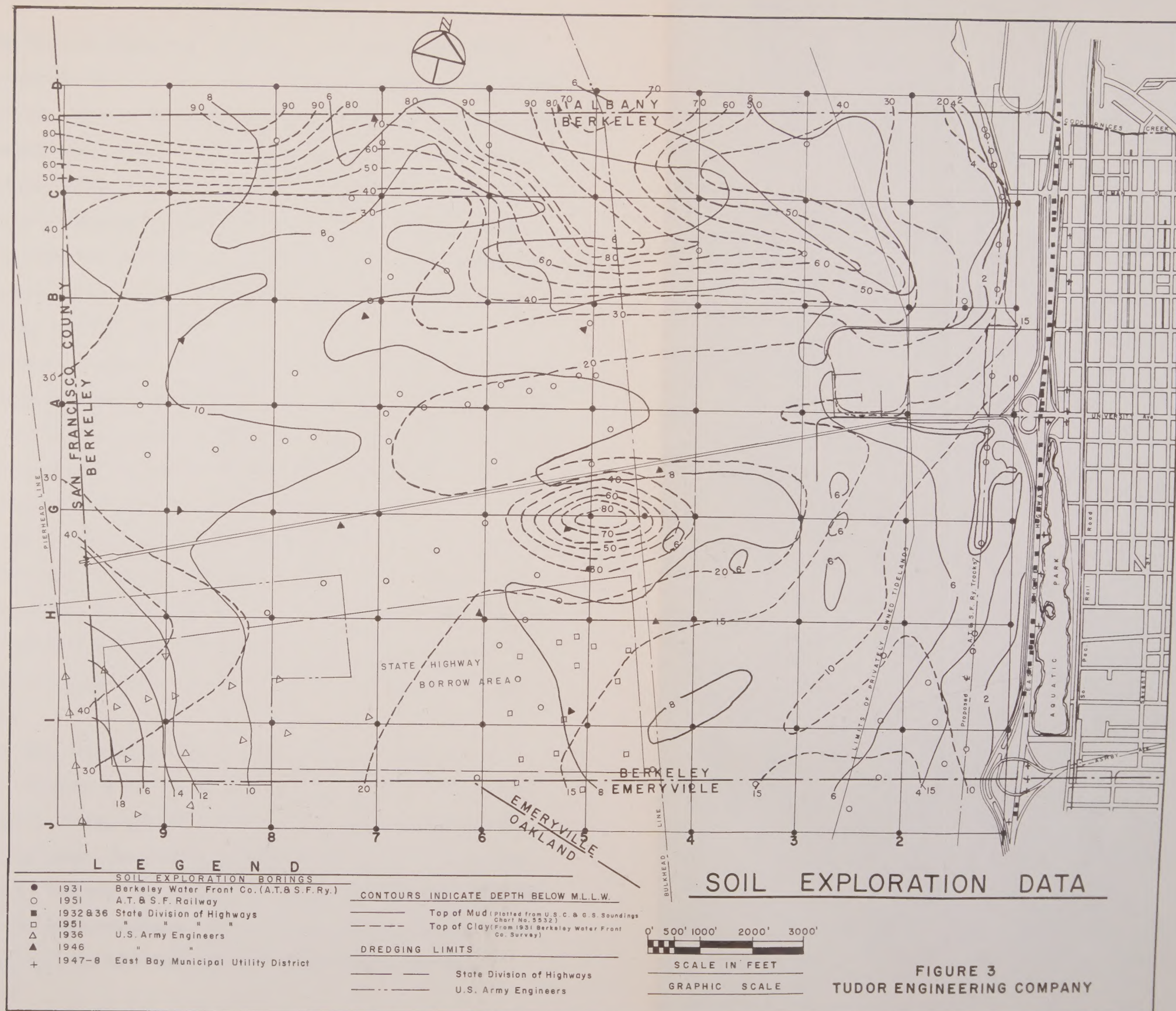
The Area to be Studied

Although no comprehensive geological explorations have been made in the vicinity of the proposed project, it has been postulated that the area is similar to other known portions of the bay. Bedrock is assumed to lie from 300 to 400 feet below sea level and to be covered to varying depths by formations of bay sediments. The oldest sediments consist of layers of firm sand, sandy clay and clay which form a good foundation for engineering structures of less than the heaviest type. The youngest formation is the bay mud which is soft, affords poor support, settles under imposed loads and fails when covered with appreciable fills.

Along the Berkeley shore the natural processes of erosion have created small valleys where streams running from the Berkeley hills removed the older sediments of firm sandy clay. These valleys were then filled with deposits of bay mud and silty clays as the sea level rose to present elevations. Such a valley is located between the Berkeley Pier and the Berkeley-Albany City limits. It is filled with mud to a maximum depth of approximately 80 feet. There is also a valley or an elliptical pocket of mud about 70 feet deep adjacent to and south of the pier. Throughout the remainder of the waterfront area the tidal flat is covered with bay mud, in varying thicknesses up to approximately 40 feet.

D. Soil Data:

Since 1931 several agencies, both public and private, have made explorations in various sections of the submerged lands. There has been some dredging in the southwest corner of the area. Locations of the various borings and dredging limits are shown on Figure 3, page 9. Although the area has been extensively explored, data available to us are not sufficiently complete to permit correlation of the various surveys. The survey explorations are summarized as follows:



The Area to be Studied

1. The Berkeley Water Front Company, a subsidiary of the Santa Fe Railway Company, made a fairly comprehensive exploratory survey of the area in 1930-31. This survey consisted of borings spaced 2,000 feet apart on a horizontal grid. Additional borings were made where stratigraphic variations were indicated between stations. Although wash borings were made, cores were supposedly taken to determine changes between various layers. All holes were drilled to a minimum depth of 40 feet below mean lower low water, or if mud was still encountered, were continued to the point of change to firm material.

Although changes in elevations of the upper mud surface may have occurred since borings were made in 1931, the elevations of the bottom of mud or top of clay are probably unchanged. However, comparison with more recent explorations indicates that the original data may not be entirely accurate. As soil mechanics was a comparatively new field in 1931, standardization had not been established. As a consequence, the analysis of these original data can not be correlated with the later results. The value of this survey is also reduced by the lack of completely published data. The logs of the borings are not shown in the report and with the exception of a few logs shown in a later report in 1936, the information is incomplete.

2. The Santa Fe Railway in 1951 again extensively explored the entire area, offshore as well as its own property. This exploration was made by Parker D. Trask, geologist, who has explored a considerable portion of the Bay Area. The results of the offshore survey have not been made available. However, the results of the survey along the centerline of the proposed track relocation, which have been made available, cannot be correlated with the 1931 Berkeley Water Front Company survey.

The Area to be Studied

3. The State Division of Highways also made extensive surveys in 1932 and 1936 along the alignment of the East Shore Highway. Their interest was primarily limited to the area along the proposed highway alignment. They found suitable subsurface conditions. The results indicated that a stable highway could be built by removing the mud, which averages about 5 feet in depth, and constructing an embankment of dredged sand. Their exploration was shallow in depth and covered but a narrow strip along the shoreline.

In 1951, prior to reconstruction of the highway, an offshore survey was made to establish the availability of suitable sand fill material in the borrow area shown on Figure 3, page 9. As a result of this survey, an agreement with the City was made to allow the State's contractor to dredge from the City owned submerged lands north of the Oakland-Berkeley City limits. In placing 2 million cubic yards of dredged sandfill, the contractor moved about 3 million cubic yards of material, the excess being mud overburden and loss of fine materials during dredging operations.

4. The U. S. Army Engineers have explored in two areas at different times. In 1936, for construction of Treasure Island, a survey was made which extended into the southwest corner of the City limits. Subsequent dredging limits were then extended as shown on Figure 3, page 9, although there is some doubt as to whether any dredging occurred within the Berkeley City limits. In 1946 the northwestern section was explored to a minor extent as part of the feasibility study of the proposed Golden Gate International Airport. The information obtained in both of these studies shows little correlation with the Berkeley Water Front Company survey of 1931.

5. The East Bay Municipal Utility District made some subsurface explorations in 1947-48 prior to the construction of the new interceptor

The Area to be Studied

sewer which parallels the East Shore Highway. This survey was local in nature and limited to use for the determination of foundation requirements for the pipe line construction and was comparatively shallow in depth. These explorations were inshore from the easterly limits of the Berkeley Water Front Company survey.

The various surveys found no rock at any location and generally found the underlying clay and mud formations to be nonuniform in consistency. The bay mud formation was found in varying thickness over the entire area having an average thickness of about 20 feet.

E. Meteorological Data:

There is considerable climatic variation throughout the Bay Area. Topography, which is the principal factor in these variations, is such that interpolation for a particular site from records of weather stations at other locations is not always accurate. However, the report on wind velocities and directions prepared as part of the study on the Golden Gate International Airport affords some indication of conditions on the Berkeley waterfront. The prevailing winds are from the southwest and west with an average velocity of about 13 miles per hour and a maximum, excluding gusts, of 32 miles per hour.

Visibility and temperature ranges were not studied due to lack of records at the site. It is assumed that these factors are similar to the other local waterfront areas and are of little significance except for airport operations and residential uses for which additional study would be required. In essence, the local offshore climate will be windy and on the colder side of the variable range of the Bay Area.

F. Hydrographic Data:

Hydrographic measurements and observations have been recorded for San Francisco Bay for a number of years by the United States Coast and

The Area to be Studied

Geodetic Survey. Their observations for tidal ranges and the 1930-31 Berkeley Water Front Company observations of tidal currents are summarized as follows:

1. Tidal Range:

The average tidal range is approximately 5 feet, the storm range is about 8 feet and the greatest range is given as 10.5 feet. Mean higher high water is +5.8 feet, mean sea level +3.2 feet and lowest tide to be expected -2.5 feet, all related to a datum of mean lower low water. The maximum high water elevation that may be expected is +8.5 feet.

2. Tidal Currents:

The 1930-31 Berkeley Water Front Company study included current observations to determine tidal velocities. These measurements indicated a strong flooding tide in the onshore direction from the Golden Gate which separates at the Berkeley Pier and a weaker ebbing tide more or less paralleling the shore from the south. Local variations have probably occurred since then due to construction of the Bay Bridge and Treasure Island. Velocity changes probably have not occurred but direction of both tides has probably changed to more nearly parallel the shoreline, with an increase in local eddy currents along the shore.

Other hydrographic factors to be considered are wave action and resulting shore erosion. Since it is well protected, San Francisco Bay has little destructive wave action. The topography is such that even with strong wind velocities, the relatively short reaches of unsheltered water tend to induce a choppy action during storms rather than large waves.

The Area to be Studied

This is indicated by the lack of erosion on the East Bay shore and of the various fills that have been placed there. However, any fills consisting of fine materials such as were used on the East Shore Highway, should be protected with a rock riprap blanket at least through the tidal range on westerly and northwesterly exposures. This will be especially important when depths are increased by dredging, thus interfering with the natural replenishment of the shoreline.

SECTION III - LAND USE

A. Plans Which Have Been Proposed:

Over the years, various proposals have been made for the reclamation and use of the tidelands and submerged lands of the Berkeley waterfront. The principal ones are as follows:

1. Santa Fe Railway Company:

The Santa Fe Railway Company is the principal tidelands owner and as such holds the key to industrial development along the East Bay shore. The railroad holdings extend from Oakland to Richmond in a strip from 2000 to 3000 feet wide along the existing shoreline. These properties have received considerable study by the railway company but the most recent study is confidential and was not made available to us. The only announced plan is one for the eventual relocation of the main line tracks to a location approximately 1000 feet offshore. Several small fills have been made along this alignment. Presumably future development will be made when economic conditions warrant.

The quantities of fill required for the holdings of the Santa Fe Railway Company along the Berkeley waterfront and for those of the Pacific Guano Company in this area, as well as the cost of land reclamation, are discussed in Section V under Possible Development.

2. Berkeley Master Plan:

The Berkeley Master Plan adopted April 12, 1955, includes among other proposals, the reclamation and development of new land area covering about one-half of the present City owned submerged lands. It is shown on Figure 4, page 16.

It is an ambitious plan. It contemplates a new, more or less self-contained 2800 acre addition to the City consisting of some 850

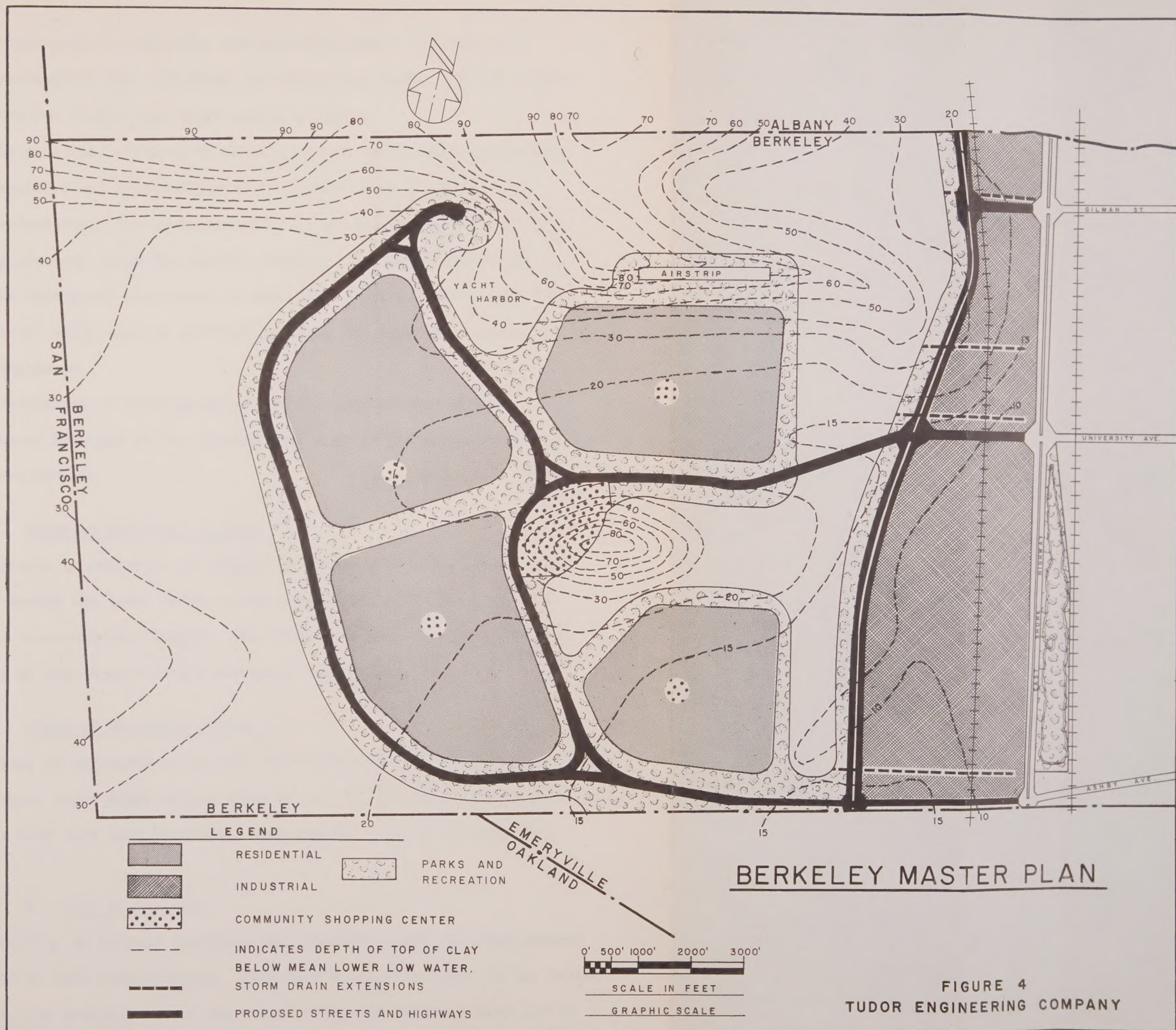


FIGURE 4
TUDOR ENGINEERING COMPANY

Land Use

acres for light industry including the privately owned holdings, 750 acres for residential use, 450 acres for recreation space, and the remaining 750 acres for streets and other public purposes.

The principal criteria of feasibility of the reclamation program are the quantities and availability of fill materials and the cost of the land reclamation. The quantities of fill materials required for this undertaking are very large for several reasons: the large area to be covered, the relatively deep water in which they must be placed, and the excess material which must be provided to allow for subsequent consolidation and subsidence.

The possibility of development of the offshore portion of the Berkeley Master Plan and of the Aquatic Park area is discussed in Section V, Possible Development.

3. Berkeley Municipal Airport:

Efforts to establish an airport in Berkeley have been made since 1928; and, during the late 1940's, efforts were made to develop the Golden Gate International Airport. The Berkeley Master Plan includes the possibility of providing a single air strip for small planes.

4. Plans of Adjoining Cities:

Plans of adjoining cities for the reclamation and development of their submerged lands might affect those of the City of Berkeley. To the extent that they have been developed, they are set forth briefly hereinafter.

a. City of Oakland:

The City of Oakland tidelands and submerged lands are administered by the Board of Port Commissioners. They have planned, as part of the harbor development, for eventual use of the area between the Berkeley City limits

Land Use

and the Bay Bridge, exclusive of the area belonging to Emeryville, for the construction of additional marine terminal facilities, along conventional lines, out to the established pierhead line. Since existing port facilities in the Bay Area have capacities several times the ocean tonnage now being moved, it is unlikely that this additional development will come into being for some time.

b. City of Emeryville:

The City of Emeryville has no definite plan at this time for development. Their submerged land holdings are of a triangular shape bounded by the City limits of Berkeley and Oakland and the Santa Fe holdings. This area is approximately 285 acres and is stated by them to be suitable for industrial use if filled.

c. City of Albany:

Development of submerged lands of the City of Albany will be difficult due to the depths of mud which covers this section of the bay. Even the privately owned (by the Santa Fe Railway) tidelands are not suitable for development in this section. For this reason, no plans have been made by the City of Albany. The City Engineer has recommended to the City Council that due to the unsuitable conditions, the area should not be developed other than on the present shoreline, and that any development there be limited to recreational purposes.

5. State Division of Highways:

The existing East Shore Freeway which is virtually completed, as presently planned, is expected to care for the anticipated increase in traffic volumes until 1970. At present, the Highway Division has no long range plans for additional facilities in this location.

Land Use

6. University of California Stadium:

A proposal made several years ago to remove Memorial Stadium and Edwards Field from the University of California campus has recently been revived and is now before the liaison committee of the Berkeley City Planning Commission for study. This proposal in its new form contemplates the removal of the stadium and Edwards Field from the campus and constructing a new stadium and accommodations for various major spectator sports on filled land to be created off the Berkeley waterfront. The proposal insofar as the proposed site is concerned has merit and is discussed in Section V, Possible Development.

7. The Welles Plan:

The Welles Plan is a land reclamation plan, developed and proposed by Professor Sam Welles, of the University of California, sponsored by the Berkeley Lions Club and endorsed in principle by the Berkeley Chamber of Commerce. This plan proposes excavating an open cut through the Berkeley Hills from just above Lake Temescal to a point on Tunnel Road about one-half mile west of the Orinda crossroads. The cut as proposed would be 2,000 feet wide at the bottom and have whatever side slopes were made necessary by the character of material encountered. The quantity of material to be excavated would be about 400,000,000 cubic yards. This excavated material would be placed on a series of conveyor belts and conveyed an average of seven miles across Oakland and Berkeley to the waterfront area where it would be used to reclaim an estimated 12,700 acres of submerged land belonging to Oakland, Emeryville, Berkeley, Albany and Richmond. The area to be filled would extend from the present shoreline westward to the pierhead line and from the Bay Bridge northward to the Richmond breakwater.

The estimated cost of this tremendous project is \$211,400,000.

The following unit costs were used: cost of land required for the cut,

Land Use

\$1,000 per acre; excavating and placing the rock and soil on the conveyor, 30 cents per cubic yard; conveying, 1.5 cents per cubic yard-mile; and spreading, or placing the material on the submerged lands, 15 cents per cubic yard.

Our analysis of this plan indicates the following conclusions:

1. The estimated excavation cost of 30 cents per cubic yard seems much too low, especially when the nature of the material is considered. The Berkeley Hills are made up largely of rock formations, not extremely hard, admittedly, but still requiring drilling and blasting, and possibly crushing, to facilitate transportation by conveyor. A minimum cost for this type of excavation, we believe, should be \$1.00 per cubic yard.

2. A conveying cost of 1.5 cents per cubic yard-mile is, in our opinion, too low even for a simple conveyor installation. A conveyor, elevated to clear overhead utility installations, and completely enclosed to eliminate dust and the hazard of falling rock through a heavily populated area, would increase the conveying cost materially.

3. The estimated placing and distributing cost of 15 cents per cubic yard could probably be met by frequent enough moving of the conveyor terminal facilities to keep trucking costs, or other means of hauling, at a minimum.

Following is a tabulation showing the Welles Plan estimated costs compared to costs we feel would be more realistic:

<u>Item</u>	<u>Quantity</u>	<u>Estimated Unit Prices</u>		<u>Estimated Total Costs*</u>	
		<u>Welles Plan</u>	<u>Our Est.</u>	<u>Welles Plan</u>	<u>Our Est.</u>
Land for cut	1,400 Acres	\$1,000	\$1,000	1.4	1.4
Excavation	400 Mil. C.Y.	0.30	1.00	120.0	400.0
Convey	2 Billion Yard Miles	0.015	0.03	30.0	60.0
Spread	400 Mil. C.Y.	0.15	0.15	<u>60.0</u>	<u>60.0</u>
Total Cost				\$211.4	\$521.4

*Millions of Dollars

Land Use

Assuming average offshore conditions of 10 feet depth of water and 10 feet of overlying mud, and an ultimate finished elevation of +15.0, we estimate that 30 feet of fill, rather than 19.5 assumed in the Welles Plan, would be required. As a consequence, only some 8,250 acres in place of 12,700 could therefore be reclaimed with the estimated amount of available material. The cost according to our estimates would therefore be \$63,300 per acre. Even using the Welles Plan estimated prices, the cost would be \$23,600 per acre in place of the stated \$15,000 per acre.

A brief preliminary letter regarding the Welles Plan will be found in Appendix C, page 68.

B. Factors Which Affect Land Use:

It is pertinent to discuss briefly some of the factors which might affect the value and suitability of reclaimed land on the Berkeley waterfront for various uses. This land will of course be in competition with other available lands in the Bay Area.

Cost is usually the most important factor though there is some variation contingent upon proposed use. Higher land reclamation costs are warranted for certain uses such as industrial or multi-story buildings than, for example, for single family dwellings and parks.

The nature and condition of the land is of course important, whether it is ready for immediate development or whether a delay must ensue before development.

Adequate rail service is important for industrial use, and convenient access to the basic system of highways is important for nearly all uses, particularly, major spectator sports.

Availability of utilities is an important factor, contingent upon the type of development. Facilities adjacent to the site could easily be

Land Use

extended to meet most service requirements.

Climate would have some effect on residential use and some types of outdoor recreation such as swimming. Objectionable odors would have an adverse effect on some types of development. Fog would affect air operations.

Hydrographic factors will have some effect. The tidal range will affect waterfront structures and storm drains to a minor degree. Waves and currents will necessitate riprapping of dredge fills on westerly and north-westerly exposures. Waves and chop will probably affect or prevent crew racing but not sailing or motor boating.

The method of land reclamation used is a significant factor. Levee construction with the land below sea level would probably be objectionable for industrial, business or residential use; but would probably be entirely acceptable for facilities for major spectator sports such as a stadium, playing fields and parking area.

In the case of dredge fills, the quality of fill materials is quite an important factor with respect to proposed land use and financing of reclamation. If the area must be reclaimed with an inferior quality of fill materials, as in this case, there will be a delay in availability of the land for development, while it is draining, consolidating and settling. Foundation conditions, which are discussed in the Dames & Moore report, Appendix A, and the type of use for which such land would be suitable, would also be affected.

The labor market is probably not a significant factor. While the Berkeley Master Plan proposes a balancing component of residential area to support the proposed adjacent industrial development, it is unlikely that the latter would be adversely affected if the residential development were omitted, in view of the nearby labor market of Berkeley as well as the adjacent cities of Oakland, Emeryville, Albany, El Cerrito and Richmond.

SECTION IV - LAND RECLAMATION METHODS

Four methods of land reclamation were considered.

A. Diking and Unwatering:

This method of land reclamation has been used extensively in Holland and river delta areas the world over, primarily for obtaining land for agricultural use. It is undoubtedly the cheapest, and often the easiest method of land reclamation when water and soil conditions are favorable, and the reclaimed land finds acceptance.

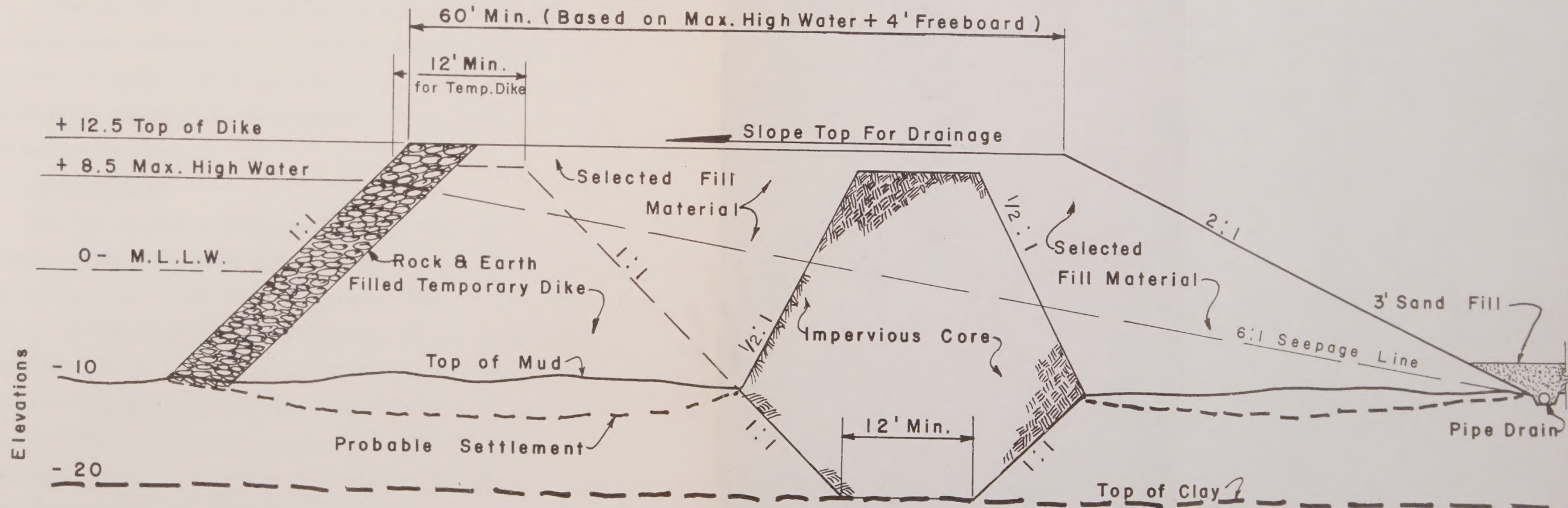
Reclamation of the Berkeley tidelands and submerged lands area by this method poses some problems. First, and probably most important, is the layer of soft mud which covers the area. Construction of permanent dikes on this mud would not be feasible because of the subsidence that would occur and because of excess seepage due to the permeable nature of the mud. We believe that the following method and sequence of construction would be feasible: first construct a temporary dike using dry fill to enclose the area to be unwatered; concurrently cover this area while still flooded by a hydraulically placed blanket of selected sand fill; then unwater the site, excavate the mud in a trench just inside the temporary dike, and backfill this trench with impermeable core material placed in the dry to elevation +10.0; and then complete the dike by constructing the toe of compacted selected fill material, also placed in the dry. Details of a recommended dike are shown on Figure 5, page 24. It is of sufficient width to accommodate a highway consisting of two traffic and two parking lanes.

The cost of constructing such a dike is estimated to be about \$200.00 per foot of length, without a rock riprap face and about \$230.00 per foot with a rock riprap facing. This cost is based on a water depth

DESIGN CRITERIA

1. Construct Temporary Rock & Earth Filled Dike with water side protected with 4' Riprap Blanket.
2. Unwater site and excavate mud to top of clay for impervious core trench.
3. Construct Impervious core of imported material to Elev. +10 compacted in lifts not exceeding 6 inches, place selected fill material concurrently.

ESTIMATED COST OF CONSTRUCTION			
Material	Quantity /Ft.	Unit Price	Cost
Rock & Earth Fill	24 C.Y.	\$ 2 . 50	\$60.00
Riprap	6 Tons	\$ 5 . 00	\$30.00
Core Excavation	8 C.Y.	\$ 1 . 00	\$ 8.00
Impervious Core	23 C.Y.	\$ 3 . 00	\$69.00
Selected Fill	40 C.Y.	\$ 1 . 50	\$60.00
Pipe Drain (12")	1 Ft.	\$ 5 . 00	\$ 5.00
Total Estimated Cost Per Foot			\$ 232.00 *
*Does not include cost of pump drainage system.			



TYPICAL SECTION
POSSIBLE DIKE CONSTRUCTION

Scale: 1" = 10'

Land Reclamation Methods

of ten feet below mean lower low water and would be less in shallower water and more in deeper water. The cost of unwatering the area behind the dike and the pumping required to maintain a dry area would depend to a large extent upon the area under consideration. There would be a continuing outlay for operating and maintenance. The unwatering cost is not included in the cost of the dike. The blanket of selected sand should have a minimum thickness of three feet. If obtainable from the City owned submerged lands, the cost might be of the order of 50 cents per cubic yard or about \$2,500 per acre for the fill. If imported from outside the Golden Gate, the cost would be about \$2.00 per cubic yard, or nearly \$10,000 per acre for the fill alone.

As far as stability is concerned, low lying land reclaimed by this method would, after consolidation, be suitable for residential and light industrial use. It might, however, not receive acceptance from an aesthetic and psychological viewpoint for those purposes. It should be suitable for a stadium and parking area.

B. Sanitary Fills:

This type of fill is primarily a means of waste disposal, with land reclamation a secondary consideration. In general, the use of the resulting land is limited to parks, golf courses and similar recreational areas. Sanitary fills, such as are at present being made in the refuse disposal areas just north of the Berkeley Pier, are light-load-bearing fills and are subject to subsidence because they are being placed on the soft mud bottom. Additional subsidence can be expected due to decomposition of the materials used for fill. This method of filling is slow, being at the rate of about five acres per year at present, but the cost is low and in Berkeley affords an excellent and needed means of refuse disposal. At the present time much of the combustible material is burned, but in the future it is

Land Reclamation Methods

expected that air pollution control will restrict burning so that as much as ten acres per year may be filled. The present fill area and the areas north to the City limits are well adapted to sanitary filling because the great depth of overlying mud practically precludes their use for any other type of land reclamation. As subsidence occurs, additional layers of sanitary fill can be added. No costs are assessed against land reclaimed by this method. Costs of disposal operations are covered by City service charges.

C. Dry Fills:

This method of reclamation is economically feasible for small areas which are readily accessible and within short hauling distance of suitable borrow materials. This method of land reclamation sometimes results from disposal of surplus materials from other sites or projects where excavation requirements permit and when it is the economical disposal solution. These conditions do not obtain in connection with the project under study. Suitable materials are not to be found within a radius of five miles of the Berkeley waterfront, making the hauling cost excessive, and this method inordinately costly. A fill of this type would cost a minimum of \$40,000 per acre.

A plan known as the Welles Plan has been proposed as a means of filling the submerged lands on the Berkeley waterfront by dry fill. It is of gigantic proportions. It is not in our opinion an economically feasible project. It is discussed in Section III - Land Use of this report.

D. Dredged Fills:

Where suitable materials are available within a reasonable distance of areas to be filled, dredged fills usually represent the least costly method for large areas of land reclamation using fills. The sand fill

Land Reclamation Methods

currently being placed by the Utah Dredging Company on the Alameda waterfront and Bay Farm Island is a prime example of a high quality, low cost, dredged fill. Some 33 million cubic yards of fill will be placed at a cost of about 35 cents per cubic yard, or less, including the cost of sand dikes.

The City of Berkeley is not so fortunate. Water depths, and therefore the required quantities of fill materials, are greater; there is a layer of bottom mud of considerable thickness; and fill materials of acceptable quality are in limited supply. As will be noted on Figure 3, a considerable area of submerged lands along the boundary with Albany consists of a mud filled valley which is suitable neither for reclamation nor as a source of dredge fill materials.

1. Sources, Quantities, Quality and Costs of Dredged Fill Materials:

The sources and quality of dredged fill materials are discussed in the Dames & Moore report, Appendix A.

It is assumed that cities adjacent to Berkeley would not relinquish fill materials from their submerged lands; therefore, the only available dredged fill materials adjacent to the reclamation site would be those within the Berkeley City limits west of the limits of privately owned tidelands. This is an area of some 4,400 acres.

Were this entire area dredged to a normal dredging depth of -50 feet, it would yield a gross amount of some 250 million cubic yards of low quality fill material, an average of about 57,000 cubic yards per acre with no allowances for loss or bulking during dredging operations. The low quality would result not only from the considerable quantities of overlying mud included in the dredged materials but also from the additional silt and clay which will be found in the underlying formations in some quantity, judging from available boring data. The low quality of this dredger run material is

Land Reclamation Methods

reflected in the amount of consolidation and the time required to attain ultimate settlement, both of which are appreciable, as indicated graphically on Plate 1, page 60, of the Dames & Moore report, Appendix A. Because of the mud and other lighter materials, the net loss in placing the fills would be appreciable. The amount retained in the case of clay materials would be about 95 per cent with some 10 to 15 per cent bulking to be expected, but when the dredged material is principally mud, only about 70 per cent would be retained with perhaps 5 per cent bulking. The net yield would therefore be of the order of about 50,000 cubic yards per acre. However, this entire area and the resulting fill materials are not available for exploitation. If we exclude the approximately 2,000 acres in the proposed offshore development included in the Berkeley Master Plan and an additional area of about 1,100 acres lying in the mud filled valley north of clay contour -40, and also the restricted cable area, the remaining 1,300 acres, if dredged to a depth of -50 would afford a net amount of only some 60 million cubic yards of fill material. If the offshore portion of the Berkeley Master Plan were reduced in scope and area, a correspondingly greater amount of fill materials would become available for possible development further inshore. The cost of this type of dredged material should be relatively low, perhaps of the order of 35 cents per cubic yard. The cost of selected materials, especially of sand for surface blankets would, however, be higher and would raise the overall cost of all material placed.

Selected sand for dikes, for a blanket over the dredged fills described above, and for selected fills for Aquatic Park and possibly the Santa Fe lands would, if available, come from the City owned submerged lands. Imported sand if used would probably come from the so-called "Potato Patch" outside the Golden Gate, and would be correspondingly costly. The

Land Reclamation Methods

Construction Aggregates Corporation furnished an estimate recently to the San Francisco Bay Toll Crossings Division of \$1.25 per cubic yard for sand, to be obtained near the site, for the proposed Southern Crossing. The cost in the quantities for Berkeley waterfront reclamation might run from \$1.50 to \$2.00 per cubic yard, dependent on quantities required. It is unlikely that remaining small quantities of sand in other Bay Area sources such as Southampton Shoals, Point Knox Shoal at Angel Island, or Presidio Shoal would reduce this cost significantly.

The estimated quantities of sand remaining in the immediate Bay Area deposits and the Potato Patch outside the Golden Gate, as shown in Geology Appendix H of the report of the Water Project Authority of June, 1955 are as follows:

<u>Location</u>	<u>Quantities - Millions of Cubic Yards</u>		
	<u>Depth</u> 0-45 Feet	<u>Depth</u> 45-80 Feet	<u>Total</u> 0-80 Feet
Southampton Shoal	2	-	2
Point Knox Shoal	5	25	30
Presidio Shoal	5	25	30
East Bay (Between Bay Bridge and Richmond)	60	-	60
Potato Patch (Golden Gate Bar)	150	950	1,100

It should be noted that these estimates of quantities were made not as a basis for the economic development of the sand deposits, but only to indicate the limits of available material. The quantity of sand in the East Bay was recognized as a poor source due to the mud overburden and the thinness of the sand lenses making up this deposit.

2. Consolidation of Dredged Fills:

The consolidation to be expected in dredged fills on the City owned submerged lands is of no less importance than the availability of fill

Land Reclamation Methods

materials, in determining the type of development which is feasible and whether the reclamation program itself is feasible. Excess quantities must be placed initially to assure, after consolidation and settlement, that the surface will still be at a satisfactory elevation above sea level. Since subsidence will be considerable, as may be noted on Plate 1, Appendix A, page 60, and will continue over a period of years, development must either be deferred or be of a character which will not be too seriously affected by such subsidence. The uneven amount of settlement which will undoubtedly occur would for example create problems in establishing and maintaining grades for streets and utility services, and maintaining stability of any buildings supported directly on such fills. The matter is discussed in the Dames & Moore report, Appendix A.

3. Mud Stripping:

Mud stripping would be warranted and desirable if the mud blanket were relatively thin and there were ample underlying materials. This is not the case on the City owned submerged lands. Exclusive of the mud filled valley and cable area, of the 187 million cubic yards of materials down to elevation -50, 42 per cent or 79 million cubic yards consist of mud, and only 58 per cent or 108 million cubic yards of underlying materials. The latter also contain some lenses and layers of mud, silt and clay. Even though acceptable mud disposal areas could be found, which is questionable, the cost of removal would be excessive and the remaining materials would not meet the requirements of the offshore portion of the Berkeley Master Plan development or even those of the alternate program suggested in this report.

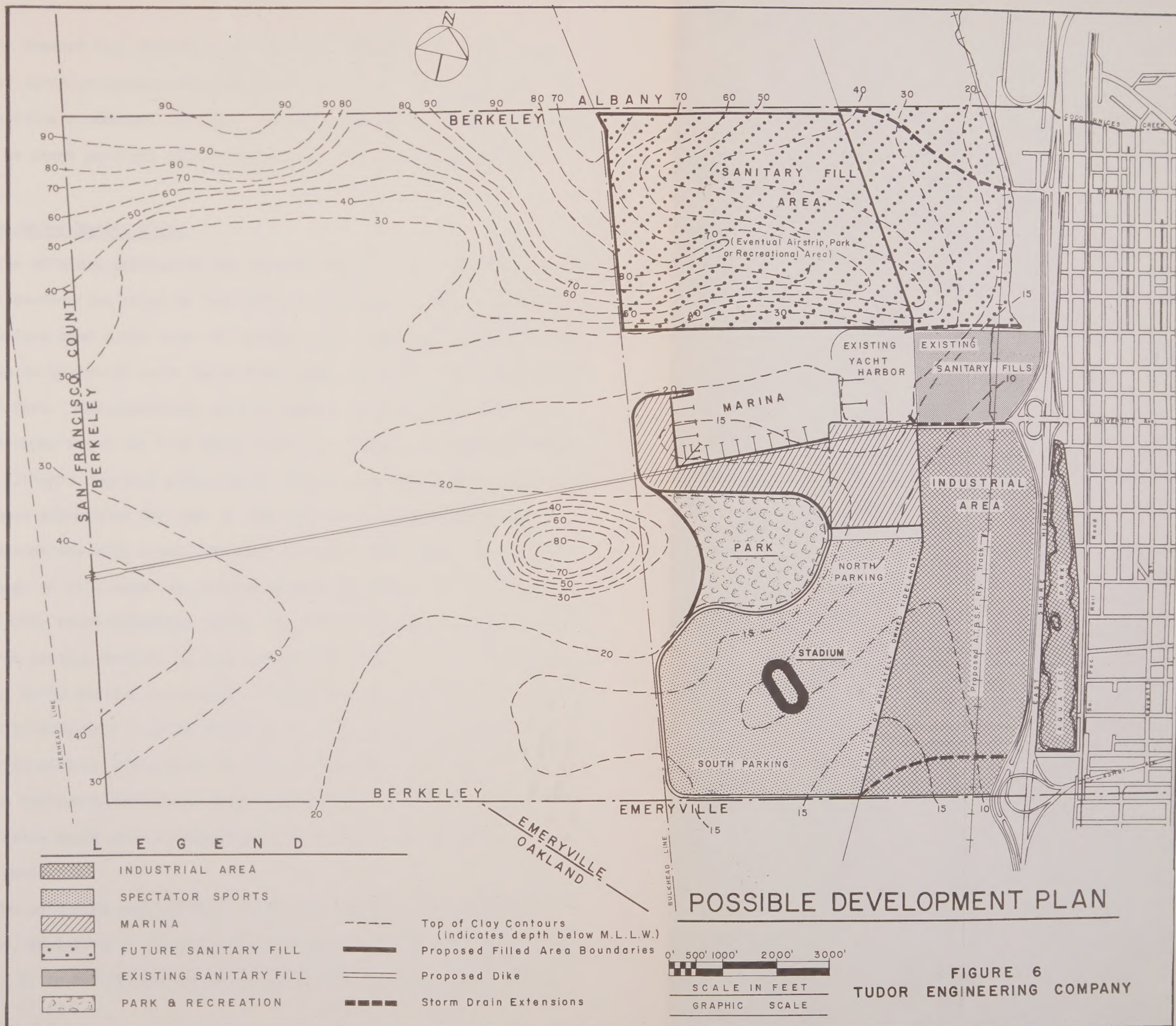
SECTION V - POSSIBLE DEVELOPMENT

The possible development described hereinafter and shown on Figure 6, page 32, is presented more to indicate along broad lines the scope and type of development possible, rather than as recommendations for these specific projects. It should be understood that the proposals are based upon limited field data which, it may be found later, do not portray the actual conditions. This has particular reference to the type and quality of subsurface materials. They may be worse or better than now seems indicated. It is understood that the City is aware that the type of development may be limited by the restrictions contained in the State Land Grant of 1913 and the 1919 amendment. We have not attempted to evaluate the effect of these restrictions upon any development proposed heretofore or herein.

The factor which is controlling with respect to feasibility of reclaiming and developing City owned submerged lands is the quality of those lands both as a source of dredge fill materials and as a base upon which to place them. Unfortunately, they are inferior in both respects.

The quantities of mud overburden and the silt and clay contained in the lower strata will result in a considerable consolidation and subsidence as mentioned and as indicated on Plate 1, Appendix A, page 60; and as a result, excess quantities of fill materials will need to be placed to allow for this settlement. This factor and the depths of water in which fill materials will need to be placed will increase costs correspondingly.

These dredge fill materials from the City owned, or from the immediately adjacent lands, if available, are nevertheless much less costly than imported fill materials such as sand from outside the Golden Gate. To import sand from the latter source would cost three to four times the



Possible Development

cost of the dredged fill materials on the site. Therefore, despite their admittedly inferior quality, the materials from the City owned submerged lands constitute a resource of value, should accordingly be conserved and allocated to those projects which will provide the greatest benefits to the City.

A. Berkeley Master Plan:

The offshore portion of the Berkeley Master Plan, exclusive of the industrial portion indicated on the Santa Fe and Pacific Guano Company holdings, comprises some 1,930 acres of residential, commercial and recreation areas lying in depths of water below mean lower low water, ranging from 6 feet to 10 feet. The quantities of fill materials other than sand, comparable to those under the City owned lands, required to bring these lands up to the ultimate required elevation of +15.0, are 106 million cubic yards. This includes allowances for loss of fine materials and bulking during dredging operations with a net loss of 9 million cubic yards. The total gross yardage of fill materials available from the remaining undeveloped portion of City owned submerged lands, exclusive of the mud filled valley in the north portion bounded by clay contour -40, and of the restricted cable area, is 60 million cubic yards. Since some 5 million cubic yards of these fill materials will be required for the Aquatic Park area and an additional 37 million cubic yards to fill the Santa Fe holdings, there would be an indicated deficiency of 83 million cubic yards of dredge fill materials which would need to come from some other source than City owned submerged lands.

The estimated cost of this offshore development of the Berkeley Master Plan, exclusive of the Santa Fe holdings as indicated in more detail in Appendix B, is \$49,400,000 or \$25,600 per acre. This includes the cost

Possible Development

of placing the dredge fill materials from City owned submerged lands and from the State controlled lands in San Francisco to the west, if available, also of a three foot sand fill using sand imported from outside the Golden Gate, and of necessary dikes and riprap protection.

From a consideration of the large quantities of dredge fill materials required, only a portion of which are available from City owned lands and also of the high cost per acre of these lands, it does not appear that the reclamation and development of this offshore part of the plan, as presently constituted, is a feasible portion of any reclamation program. Portions of the Plan, such as Aquatic Park, and the Santa Fe lands plus development of smaller offshore areas, do appear feasible and are described briefly hereinafter.

B. Aquatic Park:

In the Berkeley Master Plan, Aquatic Park, which is at present principally a water recreation area devoted to boating, is indicated as a large park. Since land available for industrial use is limited in Berkeley and since Aquatic Park would be surrounded by industrial development, it would seem appropriate that consideration be given to rezoning the 108 acres of this park area to industrial use.

There are no borings available in this area but from the borings made along the East Shore Highway it is assumed that the mud and silt overburden would average about 2 feet in depth. The approximate amount of selected dredge fill materials from the City owned submerged lands required to fill this park area up to an ultimate elevation of +15.0, is as stated, 5 million cubic yards. The estimated cost as indicated in more detail in Appendix B is \$1,800,000, or therefore, approximately \$16,700 per acre.

Possible Development

C. Santa Fe Lands:

While it is not suggested that the City of Berkeley subsidize the Santa Fe Railway Company in reclaiming their submerged lands on the Berkeley waterfront, the City does have an interest in having these lands developed for industrial use eventually in order to enlarge the City's tax base, and to afford employment opportunities. Since the materials under the City owned submerged lands are the only ones available for filling purposes at a reasonable price, it would seem advisable for the City to conserve a sufficient yardage for this purpose. The quantity required to fill the Santa Fe lands between the south City boundary and University Avenue to an ultimate elevation of +15.0 after subsidence, is 18,840,000 cubic yards including an allowance of 3.22 million cubic yards for loss of fines and of bulking during dredging operations. The estimated cost to fill the 400 acres involved, as indicated in Appendix B, is \$8,870,000 or \$22,200 per acre.

D. Marina:

Present facilities for pleasure craft are generally limited in the Bay Area and the increased public interest in this form of recreational activity indicates the need for additional facilities. The existing Berkeley Yacht Harbor provides moorings for approximately 175 small craft and is presently taxed to capacity. A waiting period as long as two years has been required in the past for individuals to obtain anchorages. This time has recently been decreased somewhat but it is still sufficiently long enough that people look elsewhere for facilities.

While the existing Yacht Harbor has not been a self-supporting municipal activity, it would appear that modern facilities could well support an expansion program. Revenues for use of facilities and concessions should be established that would be sufficient to provide for

Possible Development

operation and maintenance while increases in revenue from personal property taxes on boats and marine equipment could be utilized to help underwrite the necessary investment in non-revenue producing features.

With the above in mind, the development of a Marina is delineated on Figure 6, page 32, as an extension or supplement to the existing harbor. Development of this area would necessarily have to be done at one time and should be coordinated with the development of the adjacent areas. Construction of the anchorage and mooring facilities could be carried out over a longer period as needed. The ultimate capacity of the proposed area, including the existing basin, would handle about 2,000 small boats. Start of construction would probably generate sufficient interest to fill these facilities in a short time.

The proposed development is laid out to afford maximum protection from the prevailing winds and water currents both for the new and existing basins. Future expansion, if the need arises, could be in similar increments of additional basins paralleling the municipal pier to the west, provided that approval can be obtained for necessary relocation of the bulkhead line.

Some possible sources of financial aid other than City funds might be available for the construction of a Marina. It is possible that some funds, on a matching basis, could be obtained under the Federal Small Craft Harbor Act, which was designed to aid similar ventures. It is also conceivable that State participation with Park and Recreation funds might be obtained.

The estimated cost to reclaim the 66 acres of land is \$1,889,000 or \$28,600 per acre as indicated in Appendix B.

E. University of California Stadium:

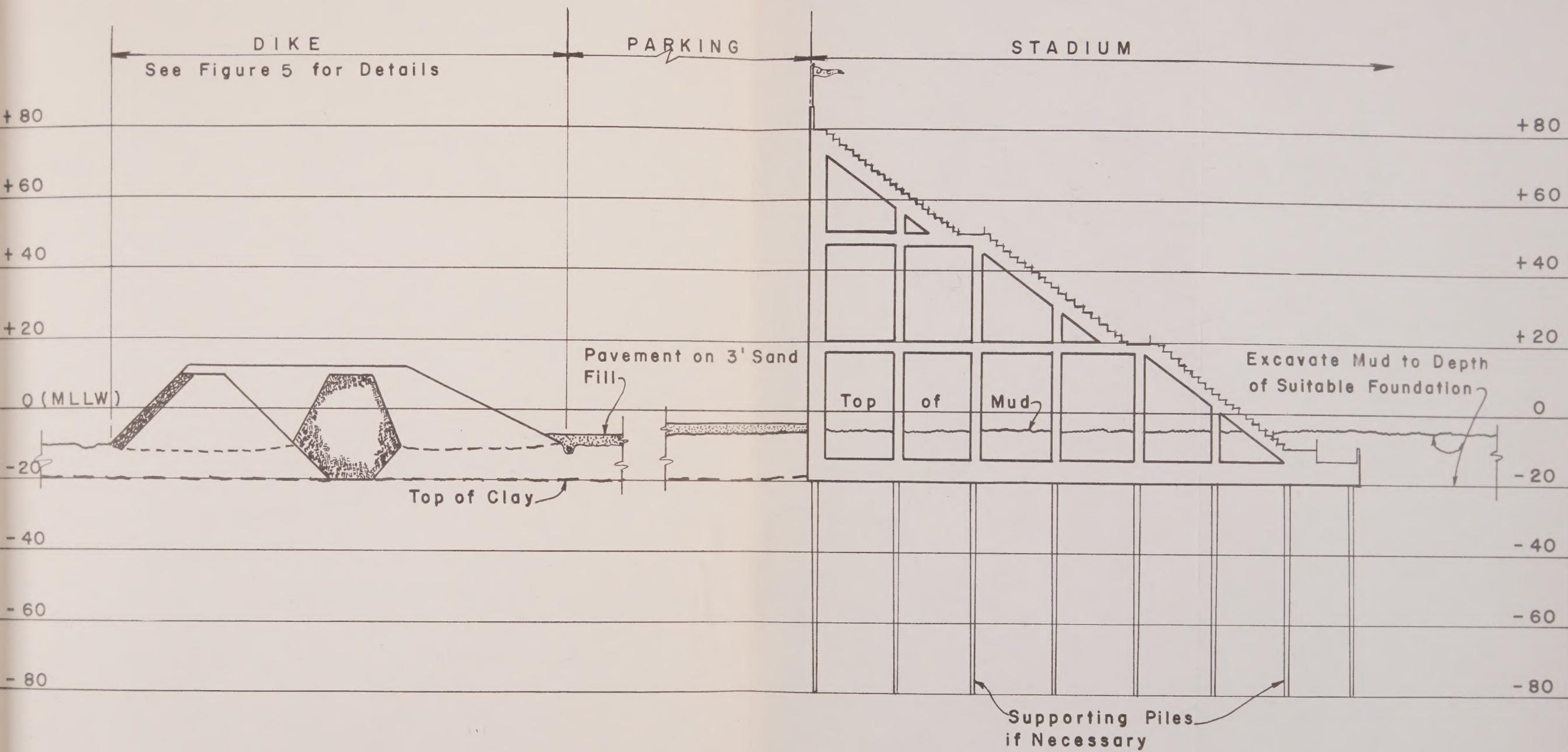
Two important requirements for a stadium and similar major facilities for spectator sports, are ready access to the basic system of highways

Possible Development

and adequate parking. These two requirements would be met by a site on the Berkeley waterfront. Another important requirement is a reasonable site cost. Because of the indicated high cost if the land were filled to elevation +15.0 as is proposed for other use, we explored the possibility of developing an area behind levees. We were of the opinion that the psychological objection to low-lying land behind levees when used for residential or industrial purposes would not apply in equal degree to more or less intermittent use for spectator sports. A possible development is indicated on Figure 6, page 32. A section through the stadium, parking area and dike is indicated on Figure 7, page 38. The estimated cost of reclaiming these 390 acres of land as indicated in Appendix B, is \$3,780,800 or \$9,700 per acre. This is based on the assumption that the fill at the north end for the proposed Marina or Yacht Harbor extension and the fill to the east on the Santa Fe lands is placed concurrently or prior to the development of the stadium and parking area. It is proposed to cover the mud over the parking area with a 3 foot blanket of selected sand fill. If the Stadium and Eastern Section of the Marina were reclaimed as a separate project, in advance of the reclamation of the Santa Fe lands, the cost would be increased to \$5,650,000 or \$12,000 per acre for the combined areas. So large an area would no doubt be valuable and used for a variety of recreational activities.

F. Waterfront Park:

In view of the dearth of large parks in Berkeley, if the present Aquatic Park is filled and developed for industrial use as was suggested above, the development of a waterfront park might be indicated. One possibility is indicated on Figure 6, page 32. Some 7.0 million cubic yards would be required to fill this area to the ultimate elevation of +15.0, including an allowance of 1.5 million cubic yards for loss of fines and bulking during dredging operations. The estimated reclamation cost



POSSIBLE STADIUM DEVELOPMENT

Scale: 1" = 30'

Possible Development

including riprap protection on the west side is \$2,396,100 for the 110 acres of land, or \$21,800 per acre, as indicated in Appendix B.

G. Dual Purpose Parking Area:

When the development of the Berkeley waterfront is agreed upon, and the detailed planning undertaken, it is probable that the paved stadium parking area may serve other adjacent activities such as the waterfront park, the Marina and such events as sailing and boat races and might also be utilized for miscellaneous sports activities.

H. Sanitary Fills:

The present system of refuse disposal by the sanitary fill method will continue to be the most economical as long as suitable fill areas are available. As discussed under Land Reclamation, Section III, there is a mud filled valley along the Berkeley-Albany City limits which can best be used as a sanitary filling area. The area shown on Figure 6, page 32, from the Privately Owned Tidelands Line to the Bulkhead Line consists of some 460 acres, all City owned. An additional area of some 220 acres toward the shore is privately owned property. The first of these areas, and also the second if it can be arranged, should be reserved for refuse disposal. At the present rate of placing sanitary fills, these areas should be sufficient for 50 to 100 years. As increments are filled, the reclaimed areas are then suitable for development for light usage, particularly for parks and recreation, and possibly for eventual development of a small airport for light planes or a heliport.

SECTION VI - EFFECT OF RECLAMATION ON EXISTING AND FUTURE FACILITIES

The effect of reclamation on existing and future facilities which is described hereinafter is predicated on the development described in Section V and not on the offshore development proposed in the Berkeley Master Plan.

A. Aquatic Park:

If Aquatic Park is filled either for industrial use as recommended in Section V of this report or as a park, there would be no effect of reclamation offshore on this area. If, however, the Santa Fe lands were filled and Aquatic Park were retained as a water area, it would be necessary to extend the five culverts which now run under East Bay Freeway connecting the bay and the lagoon, through the Santa Fe filled lands. These extensions would be costly to construct and also to maintain because of the settlement which would take place in the newly filled lands.

B. Berkeley Yacht Harbor:

If the Berkeley Yacht Harbor is enlarged as proposed in Section V, by the Marina construction, there would be no adverse effect. If, however, any development were made comparable to that indicated in the Berkeley Master Plan, it would be necessary to provide new Yacht Harbor facilities.

C. Berkeley Municipal Pier:

The Berkeley Municipal Pier will not be adversely affected by any reclamation development similar to that suggested in Section V. Any portion of the pier which falls within the area to be filled, can be incorporated in the fill and need not be removed, because the deck elevation is below that planned for the top of the fill. The outer portion can remain for use as a fishing pier. The pier will also be of use during dredging operations as a trestle support for the pipe line.

Effect of Reclamation on Existing and Future Facilities

D. Sanitary Disposal Areas:

There is no effect on the present sanitary disposal area by the possible reclamation program discussed in Section V. However, the dike now being constructed southeast of the Yacht Harbor with a view to enclosing a new sanitary disposal area south of the Yacht Harbor should be stopped. This area by reason of its location near University Avenue, and the shallow depth to clay formations, is virtually the heart of any future reclamation program and is much too valuable to be used for sanitary disposal. Such use would preclude more beneficial uses both during and following disposal operations. Sanitary disposal should be carried on in the mud filled valley to the north and northwest of the Yacht Harbor.

E. Future Berkeley Airport:

A municipal airport has long been planned for the tidelands area and a small airstrip for private planes is shown on the Berkeley Master Plan. With dredged reclaimed land costing approximately \$26,000 an acre, such a development would seem economically infeasible on the Berkeley waterfront. An airstrip, even for light planes, requires a minimum area of about 30 acres.

There is the possibility in the future that a small airport for light planes or a heliport could be developed on the lands reclaimed by sanitary fills. The feasibility of any kind of airport will need to be the subject of further study in conjunction with other plans to reclaim and develop the City owned submerged lands.

F. Future Additional East Shore Freeway:

The present East Shore Highway, although expected to be adequate until 1970, may nevertheless become outmoded before this date. If this proves to be the case, an additional freeway could readily be built along the shore of the industrial area much as the present highway was built.

Effect of Reclamation on Existing and Future Facilities

G. Existing Storm Sewers:

The existing Berkeley storm drain system has four major outlets to the bay, three of these being large reinforced concrete box conduits and one reinforced concrete pipe. As originally designed, the system was integrated with the sanitary sewer system, but the systems have now been completely separated. Studies by the City Engineer's office developed the flow data shown in the tabulation below.

During construction of the East Shore Freeway, the State Highway Department extended the outlets by construction of additional lengths of drains. Further extensions will be necessary to provide outlets for the proposed development. The most economical and feasible method would be to provide open tidal channels as shown on Figure 8, page 43, from the present outlets to the new shoreline. In this way, additional capacities could be provided for local drainage of the existing highway and the newly filled areas at minimum expense.

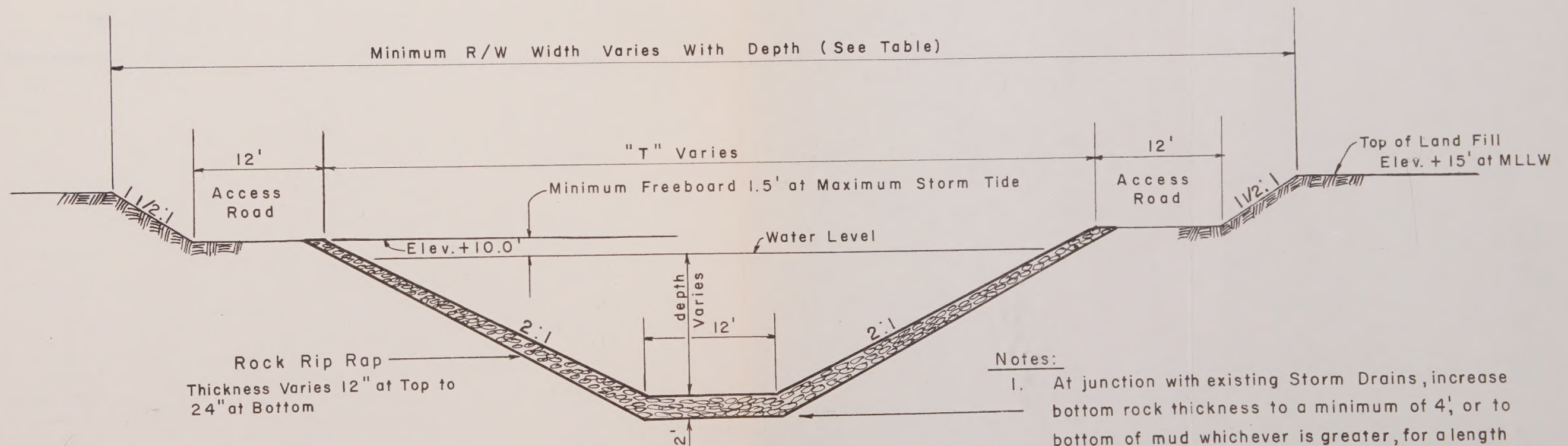
From the hydraulics standpoint, the extension of existing construction with enclosed structures would require additional energy to carry the maximum flows. This would raise the hydraulic gradient upstream creating a longer backwater reach, thus adversely affecting the drainage of the local areas between the shoreline and San Pablo Avenue.

The following tabulation, page 44, is a summary of the present storm drains and the lengths of extension required for the development proposed in Section V.

Location	Average depth	T	R/W	Volume of Rock		Rock Cost at \$5/Ton Per Foot of Channel
				C.F./Ft.	Tons /Ft.	
Potter Street	10'	52'	92'	91	4.6	\$ 23.00 / Ft.
University Avenue	19'	88'	130'	151	7.6	\$ 38.00 / Ft.
Virginia Street	16'	76'	115'	131	6.6	\$ 33.00 / Ft.
Gilman Street	16'	76'	115'	131	6.6	\$ 33.00 / Ft.

DESIGN CRITERIA

1. Riprap as Slope and Invert Protection.
2. Channel bottom width minimum of 12 ft. for Construction & Maintenance purposes.
3. Hydraulic Gradients to be determined by maximum high tide for storm range of + 8.5 ft.



TYPICAL SECTION FOR STORM DRAIN EXTENSIONS

SCALE: 1" = 10'

FIGURE 8
TUDOR ENGINEERING COMPANY

Effect of Reclamation on Existing and Future Facilities

<u>Location</u>	<u>Type*</u>	<u>Existing Structure</u>		<u>Extension Req'd</u> (Lineal Feet)
		<u>Outlet Elev.</u> (Ft. @ MLLW)	<u>Flow</u> (Cu.Ft./Sec.)	
Potter Street (North of Ashby)	8'x7' B.C.	-1.2	1,145	3,000
University Avenue	8'6"x9' B.C.	-8.5	1,030	2,000
Virginia Street	8'x7' B.C.	-5.6	398	2,200
Gilman Street	60" RCP	-5.0	182	3,600

* B.C. indicates Box Conduit; RCP indicates Reinforced Concrete Pipe

The estimated cost of extending the storm drains for the Possible Development discussed in Section V is \$337,000 as indicated in Appendix B.

SECTION VII - FINDINGS AND CONCLUSIONS

A. Findings:

1. The tidelands and submerged lands off the Berkeley waterfront consist of some 5,100 acres, larely City owned and acquired from the State, extending about 2.4 miles along the Berkeley shoreline and about 3.3 miles westerly into San Francisco Bay.
2. Water depths below mean lower low water increase gradually from the shore to a maximum of about 19 feet in the southwest corner of the area. The elevation of the highest tide to be expected is +8.5.
3. There is a mud blanket over the underlying clay and sandy clay formations varying in thickness from about 5 feet near the shoreline to about 20 feet at the west boundary. However, there is a mud filled valley along the Berkeley-Albany boundary with mud over 90 feet deep, and a pocket or possibly another valley south of the Berkeley Pier with mud perhaps 70 feet in depth.
4. The privately owned submerged lands consist of about 700 acres held by the Santa Fe Railway Company along the shoreline and some 50 acres owned by the Pacific Guano Company.
5. The Pacific Gas and Electric Company has a State license for two cable crossings through the northwest corner of the City owned submerged land area.
6. The State land grant of 1913, amended in 1919, restricts the use of the submerged lands to the establishment of a harbor and facilities for the promotion and accommodation of commerce and navigation.
7. Extensive subsurface exploration has been made of the submerged lands to determine the nature and extent of underlying materials. Not all exploration data were available to us. Available data were not

Findings and Conclusions

consistent or conclusive as to the nature of the materials.

8. Available test data indicate that the soil materials underlying the submerged lands are of inferior quality both as a source of dredge fill materials and as a base upon which to place them. Down to a normal dredging depth of -50.0, they consist of about 42 per cent mud and 58 per cent clays and sandy clays, which also contain some mud, sand and silt. These deposits have been further downgraded by the sale, on occasion, of sand from the City owned submerged lands.

9. Consolidation and settlement of the fills of materials dredged from the City owned submerged lands will be extensive, perhaps 4-1/2 feet total in a 19-1/2 foot deposit consisting principally of clay balls, placed over a 6 foot thickness of mud; up to 6 feet in a 21 foot deposit, consisting principally of mud placed on the same bottom.

10. Consolidation will take years. Fifty per cent of the total consolidation will have occurred in two years, but some 50 years will be required for complete consolidation.

11. Excess quantities of fill materials will be required to compensate for consolidation and settlement.

12. Sand deposits outside the City limits remaining in the Bay Area are in short supply and would be costly to use for fills. The cost would range from \$1.50 to \$2.00 per cubic yard in place in the fills.

13. The estimated cost in place in the fills of dredger run material in quantity from the City owned submerged lands would run about 35 cents per cubic yard. For selected materials, the cost would rise to 50 cents or 75 cents for smaller quantities.

14. Various proposals have been made for the reclamation and use of the tidelands and submerged lands off the Berkeley waterfront. One is by the Santa Fe Railway Company to reclaim their privately owned lands for

Findings and Conclusions

industrial use. They do not, however, plan to undertake this development in the immediate future. A recent proposal is to construct a stadium and parking area on the Berkeley waterfront. The most comprehensive plan is the offshore development indicated on the Berkeley Master Plan. The adjoining cities have some plans but they will not materially affect any reclamation plans of the City of Berkeley.

15. There are not sufficient fill materials on the City owned submerged lands to accomplish the reclamation program indicated on the Berkeley Master Plan. There are sufficient materials to fill the Aquatic Park area, the Santa Fe lands between the south City boundary and University Avenue and a smaller offshore development behind the established bulkhead line.

16. Four methods of reclamation were considered: diking and unwatering, sanitary fills, dry fills and dredged fills. A finished grade elevation after stabilization of +15.0 was adopted, as directed.

17. The only existing facilities presently on these tidelands and submerged lands are the Berkeley Yacht Harbor, the Berkeley Pier, sanitary fills of the City of Berkeley existing and proposed, lying north and south, respectively, of the Berkeley pier, and submarine cables of the Pacific Gas and Electric Company crossing the northwest corner of the area. The Aquatic Park which lies east of the East Shore Highway between the south City limits and University Avenue would be involved in any reclamation plans.

B. Conclusions:

1. The soil materials underlying the City owned submerged lands are of inferior quality for fill purposes because of the depth of mud overburden and the silt and clay in the underlying strata.

2. Because the mud overburden constitutes nearly one-half of the available materials down to a normal dredging depth of -50.0, and in any

Findings and Conclusions

case mud disposal areas would be difficult to find, prior stripping of the mud is not economically feasible.

3. The use of imported sand from inside or outside the Bay would be too costly for reclamation fills.

4. It is unlikely that any of the adjoining cities would make any of the materials underlying their lands available for fill purposes.

5. The soil materials underlying the City owned submerged lands being the only ones available in quantity at reasonable cost, will therefore need to be used for any reclamation program.

6. Despite their inferior quality, these soils represent an asset of value, should therefore be conserved and allocated to those projects which will be of the most benefit to the City.

7. The type of development on the reclaimed lands will need to be patterned to the type of fill materials used. Unless they are selected materials, they will be characterized principally by a considerable amount of, and length of time for, consolidation and settlement. If non-selected dredger run fills are used, development must either be deferred until consolidation has been effected, or be of a type which would not be materially affected by appreciable differential settlement. It would be difficult to maintain street and utility grades and stability of soil bearing structures in such fills.

8. Any method of reclaiming City owned submerged lands will be costly, especially further offshore. The least costly will be diking and unwatering. For the stadium and parking area, the cost will approximate \$9,700 per acre or \$12,000 per acre if undertaken as a separate project in advance of the reclamation of the Santa Fe lands and the Marina. The cost of land reclaimed by dredge fill will vary from \$16,700 per acre for selected fill for the Aquatic Park area, to \$28,600 for the dredger run

Findings and Conclusions

fills for the Marina area. No method of reclaiming any sizeable area of City owned submerged land using dry fills is considered economically feasible.

9. Development of the offshore portion of the Berkeley Master Plan is not considered economically feasible because of the non-availability of sufficient dredged fill materials and of the excessive cost if they were available.

10. A less ambitious reclamation program inside the established bulkhead line based on using fill material from the City owned submerged lands would be feasible if financing can be arranged.

11. Aquatic Park would be better suited, if filled, for industrial rather than park use. It would be in the midst of a purely industrial area and should be rezoned as such.

12. Reclamation of a replacement waterfront park area would be feasible as part of a larger reclamation program if financing could be arranged. It might be eligible for State financial assistance.

13. Because of the tax and employment benefits to the City, consideration should be given to conserving sufficient materials from the City owned submerged lands to permit the Santa Fe lands from the south City limits to University Avenue to be filled for prospective industrial use.

14. With direct access available to the primary road system, a site on the Berkeley waterfront would be suitable for a stadium, parking area and other major facilities for spectator sports.

15. Land reclaimed by diking and unwatering would probably be entirely acceptable for a stadium and parking area, but might not find acceptance for residential, business or industrial use.

16. A Marina or extension of the Berkeley Yacht Harbor to serve expanding boating and yachting activities would surely qualify under the

Findings and Conclusions

State land grant restrictions and might be eligible for Federal financial support.

17. Development of a major airport is probably not feasible. A minor air strip or heliport, however, could be a feasible development.

18. The mud filled valley in the northerly portion of the City owned submerged lands can best be utilized for needed sanitary disposal areas. If use were attempted for other purposes, fills over this deep mud would be subject to excessive settlement and pile foundations would be excessively deep.

19. The development of a new sanitary disposal area started just south of the Yacht Harbor should be discontinued. A sanitary fill in this area might preclude its use for other, more valuable purposes.

20. The clay formations underlying the bay mud will provide adequate foundations for structures likely to be built on the waterfront. A stadium would probably be supported on soil bearing foundations, possibly on piling. Structures on fill could be founded on piling or directly on the fill if very light.

21. Dikes for dredged fills can be most economically constructed using selected dredged materials. Levee type dikes can best be constructed using dry dumped fill, sealed later after the area is unwatered. Riprap will be necessary on westerly and northwesterly exposures.

22. None of the existing facilities on the tidelands or submerged lands area would be adversely affected by any of the reclamation projects suggested in Section V of the report under Possible Development, except that the City storm drains would need to be extended for nearly any type of reclamation program.

23. State land grant restrictions may prevent some types of development proposed.

Findings and Conclusions

24. Additional subsurface exploration should be made before any reclamation program is undertaken.

25. Reclamation of the City owned submerged lands lends itself to stage development provided that a sequence is followed starting inshore and working out. Costs may be higher than for a coordinated concurrent program.

APPENDIX

LOS ANGELES
SAN FRANCISCO
PORTLAND
SEATTLE
SALT LAKE CITY
CHICAGO
NEW YORK
ATLANTA
LONDON

DAMES & MOORE

SOIL MECHANICS ENGINEERS

417 MARKET STREET • SAN FRANCISCO 5, CALIFORNIA • DOUGLAS 2-6507
WILLIAM W. MOORE

March 29, 1956

Tudor Engineering Company
74 New Montgomery Street
San Francisco, California

Gentlemen:

Report
Soils Engineering Services
Proposed Development of Berkeley Submerged Lands
For the City of Berkeley

SCOPE:

This letter and attachment present the results of our studies for the subject development. The submerged lands within the limits of the City of Berkeley comprise some 5000 acres, which extend approximately 13,000 feet in a north-south direction along the East Shore Freeway and 18,000 feet in a westerly direction off-shore to the end of the Berkeley Pier. The feasibility of developing a portion of these submerged lands for industrial, residential, or recreational purposes is under consideration.

We have developed quite generalized subsidence data concerning the development of the 1930-acre Residential Area and 900-acre Industrial Area included in the Berkeley Master Plan. More detailed soils engineering studies have been devoted to the 400-acre Industrial Area and the 142-acre Marina Area shown on the Possible Development Plan, Figure 6 of the Tudor Engineering Company Report.

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Subsurface soil conditions in the submerged lands have been evaluated by reviewing available boring logs and geologic data. These data have been correlated with general information in our files to determine the probable behavior of hydraulic fills which might be used to reclaim these submerged lands. The results of our subsidence studies are included in this Report. Data which we have developed concerning the availability of hydraulic fill materials, foundation conditions in the Proposed Industrial, Marina and Stadium Areas, and recommendations for additional subsurface explorations are also summarized in this Report.

SUBSIDENCE PREDICTIONS:

The submerged lands proposed for development are blanketed with weak, compressible soils commonly referred to as bay mud. The weight of hydraulic fills placed on these bay mud formations will cause consolidation of the bay mud and subsidence of the fills. Additional subsidence of the surface of the fills will be created by consolidation of the fills under their own weight. In order to maintain a minimum elevation in the area, it is advisable to compensate for subsidence of the fills in the initial filling operations. The magnitude and rate of the subsidence depends upon the depth and lateral extent of the natural soils and fills and upon the consolidation characteristics of these soils.

Subsidence patterns for the Proposed Industrial and Marina Areas are presented on the attached Plate. (The subsidence patterns of the Residential Areas proposed in the Berkeley Master Plan are roughly

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similar to those indicated for the Proposed Marina Area.) The assumed elevation of hydraulic fill placement was based upon a final grade of $+15$ (MLLW = 0) in 50 years.

Our analyses have assumed that the hydraulic fills would be obtained by dredging the area west of the Proposed Industrial Area to an elevation of -50 . Within this dredge depth, four geologic formations are encountered, (1) Bay mud, (2) Merritt sand and sandy clay, (3) Posey clay, sandy clay and sand, and (4) San Antonio formation of firm clay, sandy clay and gravel. The thicknesses and physical properties of these formations vary greatly within the Berkeley submerged lands. As requested by your Engineers, we have considered that the fill would be "run of dredge", with the exception of the upper three to five feet which would be a hydraulic sand blanket. It has been assumed that the run-of-dredge hydraulic fill would consolidate under its own weight for about two years prior to the placement of the sand blanket. The variable character of the hydraulic fill was estimated by assuming two types of fill for which separate subsidence patterns were developed. The run-of-dredge fill which would produce the minimum subsidence would consist primarily of clay balls with some bay mud and sand. The fill causing the greatest subsidence would consist principally of bay mud with some clay balls and sand.

It should be realized that the subsidence patterns presented in this Report are only approximations. Several factors prevent the calculation of more accurate subsidence data. Although the general

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subsurface conditions in the Proposed Industrial and Marina Areas are known, specific data on the physical properties of the natural soils are limited to small sections of these areas. However, it is believed that the assumed "average natural soil conditions" in the Industrial Area and the assumed "minimum and maximum thicknesses of natural bay mud" in the Marina Area are representative of the actual soil conditions in these areas. There is greater uncertainty in estimating the probable character and behavior of the run-of-dredge hydraulic fills, as the subsurface conditions in the proposed borrow areas are not accurately known and the manner in which the materials may be dredged and deposited is subject to wide variations. Consequently, the magnitude and time rate of subsidence of the non-homogeneous hydraulic fills cannot be calculated to a close degree of accuracy; nor is there any broad experience regarding the behavior of run-of-dredge hydraulic fill on which empirical subsidence estimates can be based. We have evaluated the probable subsidence of the run-of-dredge fills by first considering the behavior of the homogeneous bay mud and clay ball fills, and then readjusting the subsidence for estimated variations in the run-of-dredge fills.

We wish to point out that the lack of precision in the subsidence estimates does not mean that the proposed methods of submerged land reclamation are impractical from a soils engineering standpoint. It is our opinion that the subsidence data presented in this Report are of sufficient accuracy for preliminary studies to evaluate the general feasibility of the development. Additional subsurface exploration

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and analyses, and perhaps the construction of a test fill during the design period, would permit more accurate estimates of the long-term subsidence behavior of the fills prior to the development of the area.

AVAILABILITY OF HYDRAULIC FILL MATERIALS:

Reclamation of the Berkeley submerged lands will require large quantities of fill material. The use of hydraulic fill available near the proposed development is required to make the reclamation economically feasible. The Merritt or Posey formations provide the best source of hydraulic fill in the Bay Area. Unfortunately, these deposits do not appear to be in sufficient quantity within the limits of the City of Berkeley and adjacent lands to permit their exclusive use as a source of hydraulic fills. Between the San Francisco-Oakland Bay Bridge and the City of Richmond, the available borrow sand averages about five feet in thickness and is overlain by a bay mud cover of about 20 feet in average thickness. Thus, it is necessary to strip a considerable volume of bay mud to develop any large sand deposits in this area. Within the Berkeley submerged lands, the most extensive deposits of borrow sand seem to lie along the southerly City Limits. It is estimated that there are from 10,000,000 to 30,000,000 cubic yards of borrow sand above Elevation -50 in the Berkeley City limits. However, the location and distribution of the sand deposits cannot be accurately determined on the basis of available data. Additional subsurface exploration may indicate the feasibility of developing borrow areas within the Berkeley City Limits for the hydraulic sand blanket to be placed in the Proposed Industrial, Marina and Stadium Areas.

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Other sources of hydraulic sand in the San Francisco Bay Area are described in the geologic report on the Bay Barrier System compiled by the State of California, Department of Public Works, in June 1955. The largest deposits of sand are located on the Golden Gate Bar; this area may provide the best source of borrow sand if it is necessary to import this material.

FOUNDATION CONDITIONS, PROPOSED INDUSTRIAL, MARINA AND STADIUM AREAS:

If uniform hydraulic fill materials were used in reclaiming the submerged lands, the consolidation of the fills under their own weight would be relatively uniform, and the differential subsidence of the fills would be created primarily by the differences in consolidation characteristics and depths of the compressible natural soils. The use of variable run-of-dredge fill materials will create greater differential subsidence of the surface of the fills. This differential subsidence will create problems in the establishment and maintaining of grades for streets and utility services, and in the settlement behavior of buildings supported by the fills.

Foundation requirements for buildings constructed in the Industrial and Marina Areas will be dependent upon the sizes and weights of the buildings and upon their sensitivity to total and differential settlements. Light, flexible structures which can stand considerable settlement could be supported on spread footings founded in the sand fills. Heavy industrial structures would probably have

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to be pile supported. Moderately heavy buildings could be supported either on piles or on rigid, girder type foundations capable of minimizing the differential settlements of the structures.

We understand that you propose to support the stadium on a mat founded on the natural soils below the bay mud. It is our opinion that a mat foundation will adequately support the stadium loads.

RECOMMENDATIONS FOR ADDITIONAL SUBSURFACE EXPLORATIONS:

The largest number of borings in the area were drilled for the Berkeley Water Front Company in 1931. These borings were also the most extensive in area coverage. Unfortunately, very little soil engineering data are available from this Investigation. The logs of these borings which we reviewed do not correlate with other boring logs in the area. The recorded data in the Berkeley Water Front Company Report on the percentage of sand and mud at Elevation -35, the percentage of sand in clay, and contours of the top of the clay strata do not provide any significant engineering properties or reliable data for analyzing subsurface behavior.

Although the Atchison, Topeka & Santa Fe Ry. investigation of 1951 and the Corps of Engineers investigation for the Golden Gate Airport in 1946 provide reliable engineering data, their area coverage is limited. Additional subsurface explorations would be required in the Proposed Industrial and Marina Areas to determine accurate subsurface profiles and to predict the behavior of the natural soils under the weight of the hydraulic fills. It is our opinion that borings on a

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grid spacing of 500 to 1000 feet will provide sufficient subsurface information for planning the development of the area. The borings would also serve the useful purpose of determining the location of buried mud valleys which traverse the area. (Such a mud valley is indicated west of Virginia or University Avenues in Berkeley but additional borings would be required to determine its depth and lateral extent.)

Investigations for borrow sands which have been made from time to time along the southerly City Limits provide useful information on hydraulic fill sources. It is recommended that this information be supplemented by additional borings to determine the best source of fill materials and to evaluate more definitely the character of the dredge fills which would be available for use in the reclamation of the submerged lands.

The subsurface exploration program should include the preparation of accurate logs of test borings and the extraction of undisturbed samples for visual examination and laboratory testing. These data would provide the basis for comprehensive subsidence and foundation studies relative to the development of the submerged lands.

Yours very truly,

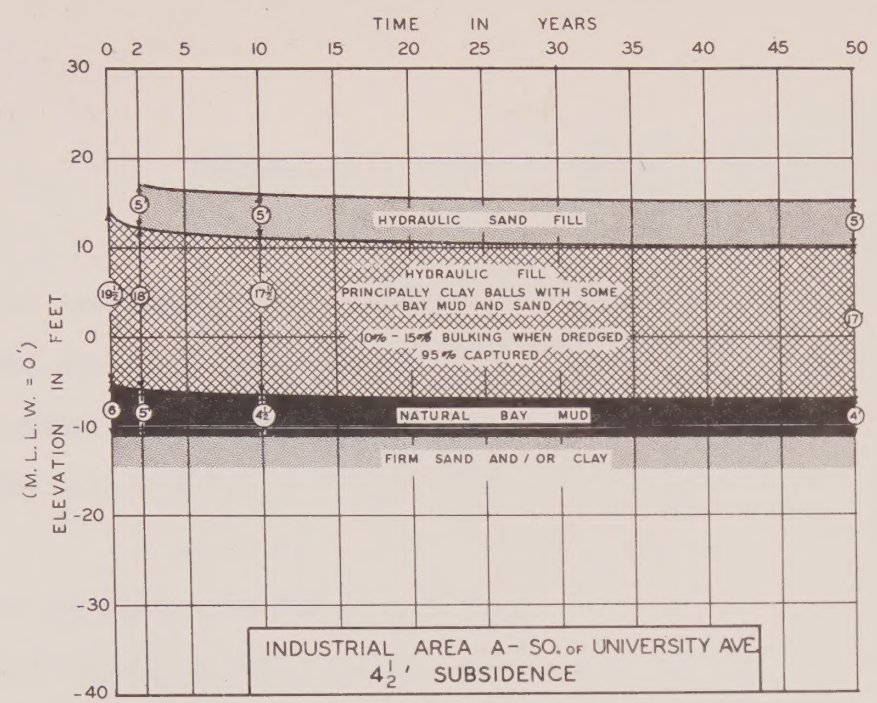
DAMES & MOORE

William W. Moore

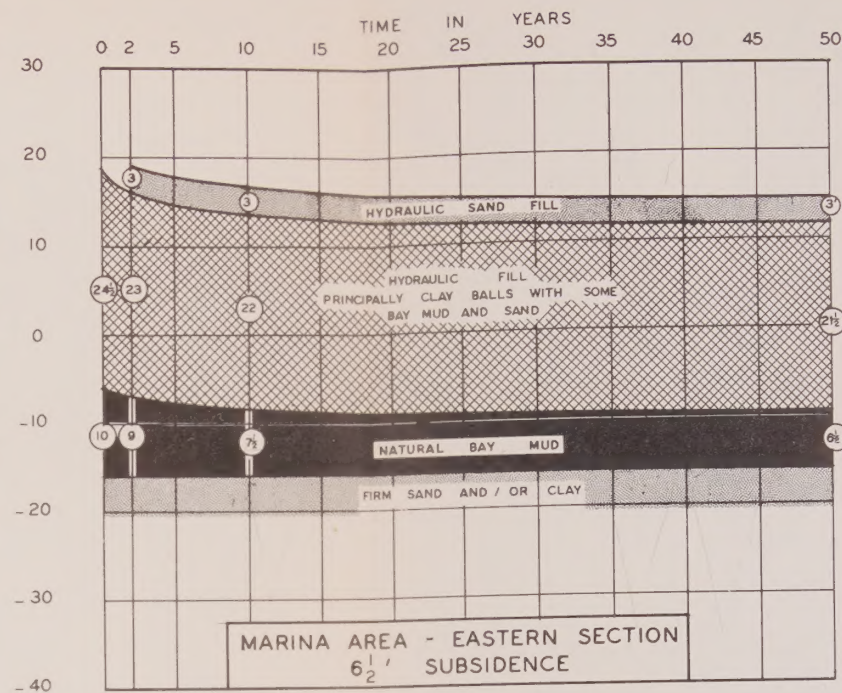
William W. Moore

by Robert J. Hanson

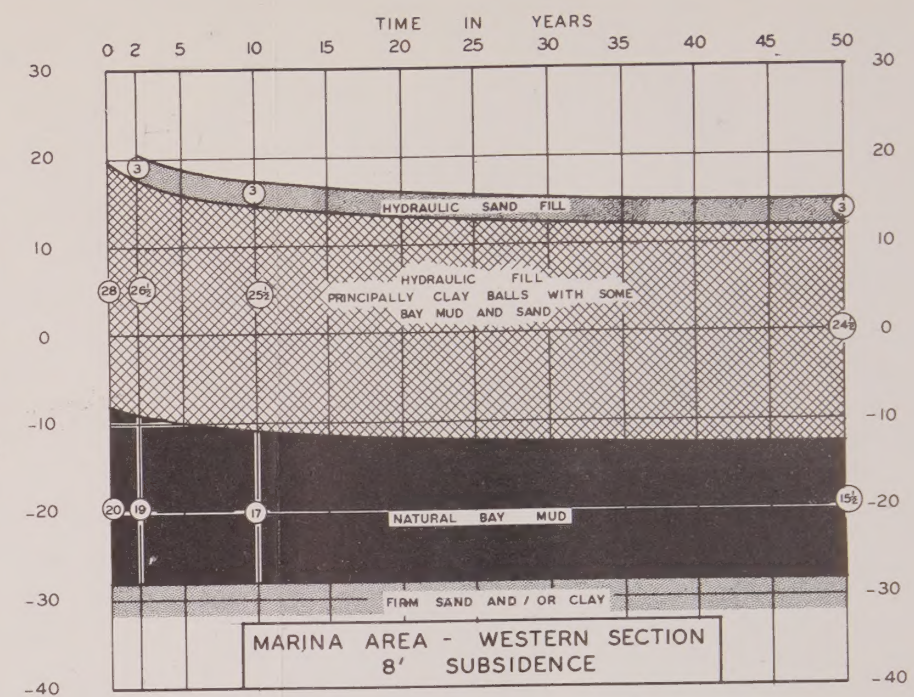
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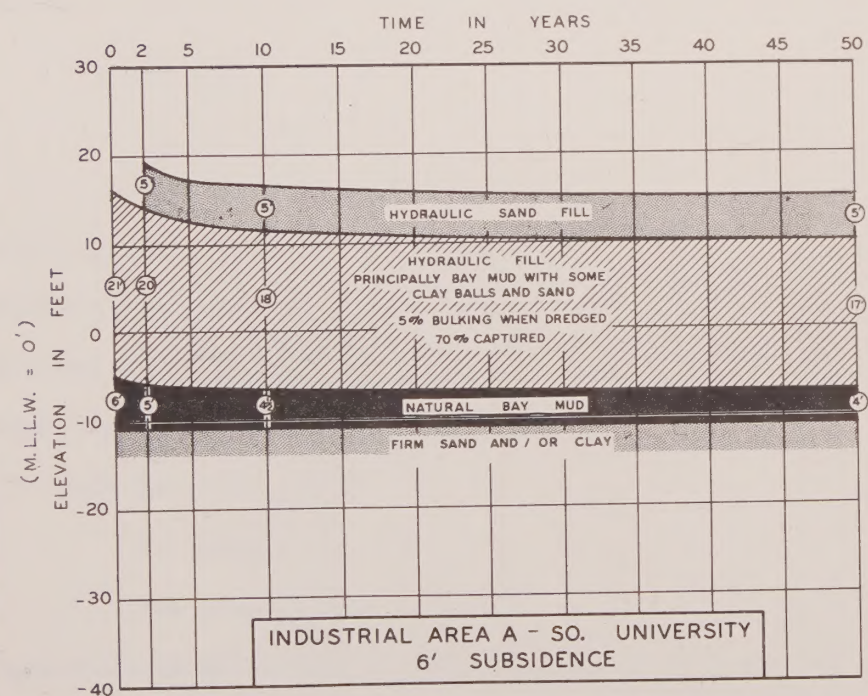
MINIMUM SUBSIDENCE PATTERN FOR AVERAGE
NATURAL SOIL CONDITIONS AND
"BEST" RUN OF DREDGE FILL



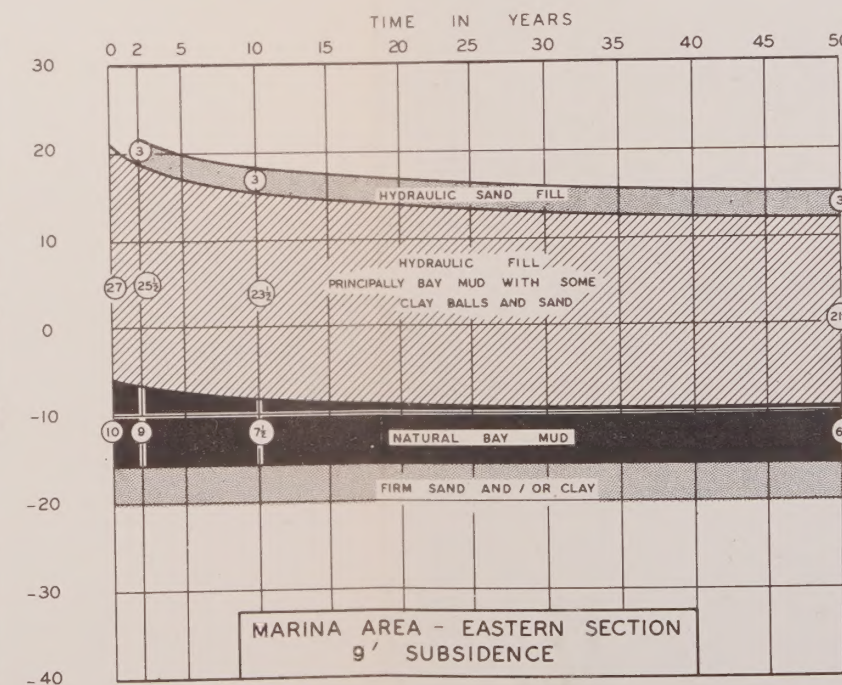
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THICKNESS OF NATURAL BAY MUD AND
"BEST" RUN OF DREDGE FILL



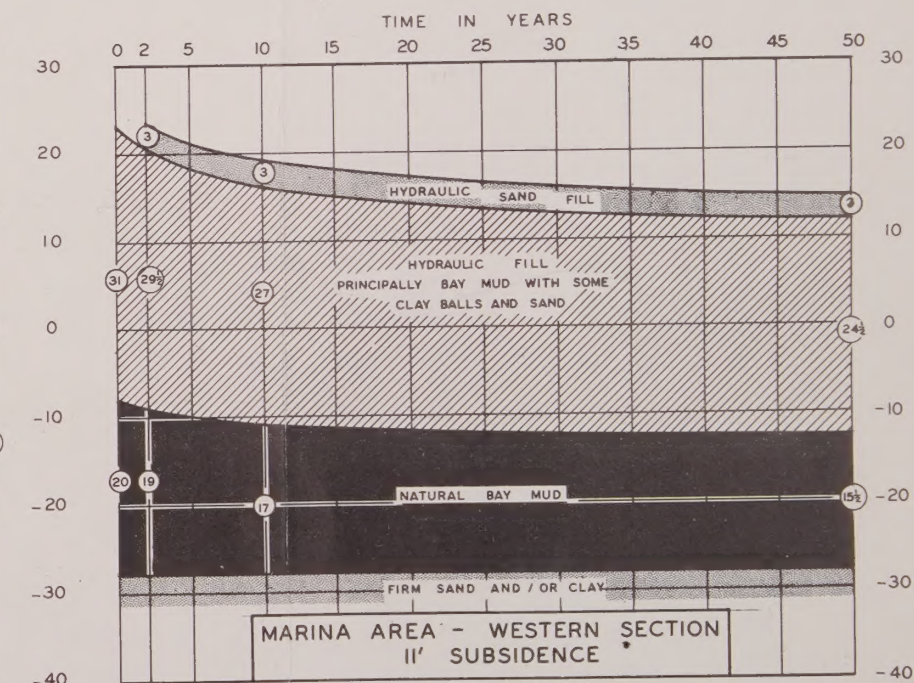
MINIMUM SUBSIDENCE PATTERN FOR MAXIMUM
THICKNESS OF NATURAL BAY MUD AND
"BEST" RUN OF DREDGE FILL



MAXIMUM SUBSIDENCE PATTERN FOR AVERAGE
NATURAL SOIL CONDITIONS AND
"POOREST" RUN OF DREDGE FILL



MAXIMUM SUBSIDENCE PATTERN FOR MINIMUM
THICKNESS OF NATURAL BAY MUD AND
"POOREST" RUN OF DREDGE FILL



MAXIMUM SUBSIDENCE PATTERN FOR MAXIMUM
THICKNESS OF NATURAL BAY MUD AND
"POOREST" RUN OF DREDGE FILL

- SUBSIDENCE PATTERNS -
INDUSTRIAL AND MARINA AREAS

ESTIMATED COSTS AND CONSTRUCTION SCHEDULE

For purposes of estimating, it was necessary to establish or assume the characteristics of available fill materials since quantities required and costs will vary with the soil characteristics. The Dames & Moore report, Appendix A, and other available soil data were analyzed for this purpose. The following are the bases used for the estimates.

It should be noted that these estimates of costs are representative of the construction costs for reclamation only. No additions have been made for engineering or financing costs nor has the usual contingency allowance been made. It was felt that the cost of these items would vary in a range between 10 and 20 per cent of the costs shown and are dependent upon the scope of the development.

A. Possible Development:

1. Aquatic Park:

There are probably sufficient quantities of sand, similar to that dredged for the East Shore Highway, available offshore to fill the Aquatic Park area. To develop this material will require selective dredging and it is assumed that approximately twice the ultimately placed volumes will have to be handled. The unit price of sand in place is estimated at 75 cents per cubic yard.

2. Industrial Area:

The size of this area precludes the probability that sand fill materials in sufficient volumes are available for other than a surface blanket. We have therefore assumed that a hydraulic fill mixture approximating the better mixture as reported by Dames & Moore, Appendix A, can be developed by selective dredging. The characteristics would be about 95 per cent captured with 10 per cent bulking or an ultimate placed volume of

105 per cent of the predredged volume. It is estimated that this material will cost approximately 50 cents per cubic yard in place.

To provide a suitable surface for foundations and pavement, it is deemed necessary by our Soils Mechanics Engineers that a 5 foot thick sand blanket be placed for the upper surface of the industrial area. This material will be similar to that obtained for the Aquatic Park fill and we estimate would cost about 75 cents per cubic yard in place.

3. Marina Area:

The balance of materials available for dredging of the hydraulic fills will in all probability fall between the limits of the two mixtures presented by Dames & Moore. The available soil data indicate the proportions to be about 42 per cent of principally bay mud and 58 per cent other than bay mud. We have accordingly, by interpolation, arrived at a mixture with characteristics of 85 per cent captured in dredging and 8 per cent bulking, or an in place volume of 92 per cent of the predredged volume. The estimated total subsidence for a 26 foot thickness placed on a 10 foot layer of mud in place would be about 8 feet. It is estimated this fill could be placed for 35 cents per cubic yard.

A sand fill blanket with a minimum thickness of 3 feet should be placed over this area. This would be similar to the blanket for the other areas and the estimated price would be 75 cents per cubic yard.

Within the Marina basin, rock bulkheads will be required to retain the fill on slopes of 1:1 to permit float and mooring construction. These bulkheads will have to be carried to the bottom of the basin which it is assumed would be dredged to a depth of 20 feet below mean lower low water. Present rock quarries in the Bay Area have sufficient reserves to deliver the necessary rock tonnages. It is estimated the cost of the rock

in place would be \$5.00 per ton. Additional rock will be required to rip-rap the exposed bay slopes through the tidal range. This would consist of a 4 foot thick blanket from elevation +10 to -5 on a 2:1 slope. The cost in place would be the same as that of the bulkhead rock, or \$5.00 per ton.

4. Stadium and Parking Area:

It is proposed that this area be enclosed on the water side by a dike as shown on Figure 5. The estimated cost is \$232 per lineal foot as shown thereon. The sand blanket of a minimum thickness of 3 feet would be similar to that used in the other areas. No paving or treatment to prevent drifting of the sand are included.

B. Berkeley Master Plan:

The large quantity of materials required for developing the Berkeley Master Plan area preclude the possibility of obtaining these materials within the City boundaries. It is assumed that dredging of similar materials from the State controlled lands to the west of the Berkeley City limits would be used. If this material is not available, the estimated total cost would be increased greatly by having to use imported sand.

Due to the extent of the offshore area proposed for development, the dredging area on City owned lands is much restricted. It is therefore assumed that sufficient sand for the surface blankets would be obtainable locally only for the Aquatic Park and industrial areas south of University Avenue. The sand for the offshore area and north of University Avenue along the shore would have to be imported at a minimum estimated cost of \$1.50 per cubic yard.

The hydraulic fill materials for these areas is assumed to be of the same quality as was estimated for the Marina area described above.

C. Possible Construction Schedule:

Based upon the capabilities of a modern large capacity dredge, such as now in use by Utah Dredging Company in Alameda, we have developed a Possible Construction Schedule. This schedule was made for the same stages and sequence of operations as were the cost estimates for the Possible Development shown on Figure 6. No schedule has been made for the Berkeley Master Plan.

ESTIMATED COSTS

BERKELEY MASTER PLAN

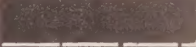
<u>Item</u>	<u>Description</u>	<u>Approximate Area Acres</u>	<u>Depth of Fill Ft</u>	<u>Quantity</u>	<u>Unit</u>	<u>Unit Price</u>	<u>Unit Amount</u>	<u>Total Amount</u>	<u>Cost Per Acre</u>
I	AQUATIC PARK								
	Selected Fill in Place	108	19	2,400,000	C.Y.	\$0.75	\$ 1,800,000	\$ 1,800,000	\$ 16,700
II	INDUSTRIAL AREAS								
	A. South of University Ave., Hydraulic Fill in Place	550	20	17,700,000	C.Y.	0.50	8,850,000		
	Selected Sand Fill in Place		5	4,430,000	C.Y.	0.75	3,322,500		
	Rock Riprap			40,500	Tons	5.00	202,500	12,375,000	22,500
	B. University Ave. to Virginia Street	85	5	690,000	C.Y.	1.50	1,035,000	1,035,000	12,200
	C. Virginia St. to No. City Limits	224							
	Hydraulic Fill in Place			9,000,000	C.Y.	0.35	3,150,000		
	Imported Sand Fill		25	1,800,000	C.Y.	1.50	2,700,000		
	Rock Riprap		5	30,000	Tons	5.00	150,000	6,000,000	26,800
III	OFFSHORE AREA								
	Hydraulic Fill in Place	1930	31	97,000,000	C.Y.	0.35	33,950,000		
	Imported Sand		3	9,400,000	C.Y.	1.50	14,100,000		
	Rock Riprap			270,000	Tons	5.00	1,350,000	49,400,000	25,600
IV	STORM DRAIN EXTENSIONS								
	Potter Street			3,500	L.F.	23.00	80,500		
	University Avenue			2,600	L.F.	38.00	98,800		
	Virginia Street			2,200	L.F.	33.00	72,600		
	Gilman Street			2,000	L.F.	33.00	66,000	317,900	
	Total Area	2897						TOTAL COST TO DEVELOP BERKELEY MASTER PLAN \$70,927,900	Average \$24,500

ESTIMATED COSTS

POSSIBLE DEVELOPMENT
(Described in Section V)

Item	Description	Approximate Area Acres	Depth of Fill Ft.	Quantity	Unit	Unit Price	Unit Amount	Total Amount	Cost Per Acre
I	AQUATIC PARK								
	Selected Fill in Place	108	19	2,400,000	C.Y.	\$ 0.75	\$ 1,800,000	\$ 1,800,000	\$16,700
II	INDUSTRIAL AREA								
	(South of University Ave.,)	400							
	Hydraulic Fill in Place		20	12,900,000	C.Y.	0.50	6,450,000		
	Hydraulic Sand Blanket		5	3,220,000	C.Y.	0.75	2,420,000	8,870,000	22,200
III	MARINA (EASTERN SECTION)	76							
	Hydraulic Fill in Place		26	3,200,000	C.Y.	0.35	1,120,000		
	Hydraulic Sand Blanket		3	368,000	C.Y.	0.75	276,000	1,396,000	18,400
IV	MARINA (Western Section)	66							
	Hydraulic Fill in Place		30	3,500,000	C.Y.	0.35	1,225,000		
	Hydraulic Sand Blanket		3	320,000	C.Y.	0.75	240,000		
	Rock riprap			44,000	Tons	5.00	220,000		
	Rock Bulkhead			40,800	Tons	5.00	204,000	1,889,000	28,600
V	STADIUM AREA	390							
	Hydraulic Sand Blanket		3	1,890,000	C.Y.	0.75	1,418,000		
	Dikes								
	-20' Depth			4,500	L.F.	232.00	1,044,000		
	-20' to -15' depth			700	L.F.	220.00	154,000		
	-15' depth			5,600	L.F.	208.00	1,164,800	3,780,800	9,700
VI	WATERFRONT PARK	110							
	Hydraulic Fill in Place		30	5,433,000	C.Y.	0.35	1,900,000		
	Hydraulic Sand Blanket		3	535,000	C.Y.	0.75	401,100		
	Rock Riprap			19,000	Tons	5.00	95,000	2,396,100	21,800
VII	STORM DRAIN EXTENSIONS								
	Potter Street			3,000	L.F.	23.00	69,000		
	University Avenue			2,000	L.F.	38.00	76,000		
	Virginia Street			2,200	L.F.	33.00	72,600		
	Gilman Street			3,600	L.F.	33.00	118,800	336,400	
Total Area		1150		TOTAL CONSTRUCTION COST FOR POSSIBLE DEVELOPMENT			\$20,468,300	Average \$17,800	

APPENDIX B
POSSIBLE DEVELOPMENT
 POSSIBLE CONSTRUCTION SCHEDULE BY STAGES

STAGE	AREA	FIRST YEAR	SECOND YEAR	THIRD YEAR	FOURTH YEAR	FIFTH YEAR
I	AQUATIC PARK Selected Hydraulic Fill					
II	INDUSTRIAL AREA Hydraulic Fill Sand Fill					
III	MARINA (Eastern Section) Hydraulic Fill Sand Fill Rock Bulkhead & Riprap					
IV	MARINA (Western Section) Hydraulic Fill Sand Fill Rock Bulkhead & Riprap		 			
V	STADIUM AREA Diking Sand Fill			 		
VI	WATERFRONT PARK Hydraulic Fill Sand Fill					

TUDOR ENGINEERING COMPANY

January 31, 1956

Our File No. 168

Mr. James A. Barnes
Director of Planning
City Hall
Berkeley, California

Dear Mr. Barnes:

This letter has reference to your letter of January 16.

We will confine ourselves, as I believe you intended, to the engineering and cost feasibility of obtaining waterfront fill material from some part of the nearby Berkeley hills.

Without going into details, it appears that the economic feasibility of reclaiming submerged lands on the Berkeley waterfront will hinge upon finding the least costly means and material sources for filling these lands. Rock and earth which has been excavated and transported from the nearby Berkeley hills, irrespective of aesthetic considerations and disruption of highways and utilities thereby involved, is not a low-cost material.

We know from experience that even easily dredged material pumped a few thousand feet costs 35 cents to 40 cents per cubic yard. As dredging is currently the best method of handling large quantities of fill materials, it would seem that the 30 cents estimate for excavating and moving the rock and earth in the Broadway Tunnel area is entirely too low. Certain problems that can be anticipated in constructing and operating a conveyor belt system across populated areas of Oakland and Berkeley between the cut area and the waterfront would probably double the conveyance cost stated. Such a conveyor system would undoubtedly need to be completely enclosed to prevent damage from soil material, to keep fine material from blowing away in high winds and to keep the material being transported on the conveyor belt from becoming too wet to handle.

If an appreciable amount of the material to be excavated is rock, the estimated excavation costs would be further out of line. In short, we do not consider the estimated costs in the description of the project which was furnished to us as realistic.

We will comment further on this point in our report but perhaps the above will suffice for the present.

Very truly yours,

TUDOR ENGINEERING COMPANY

HPO'R:sfb

H. P. O'Reilly

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